Sustainable Trail Layout

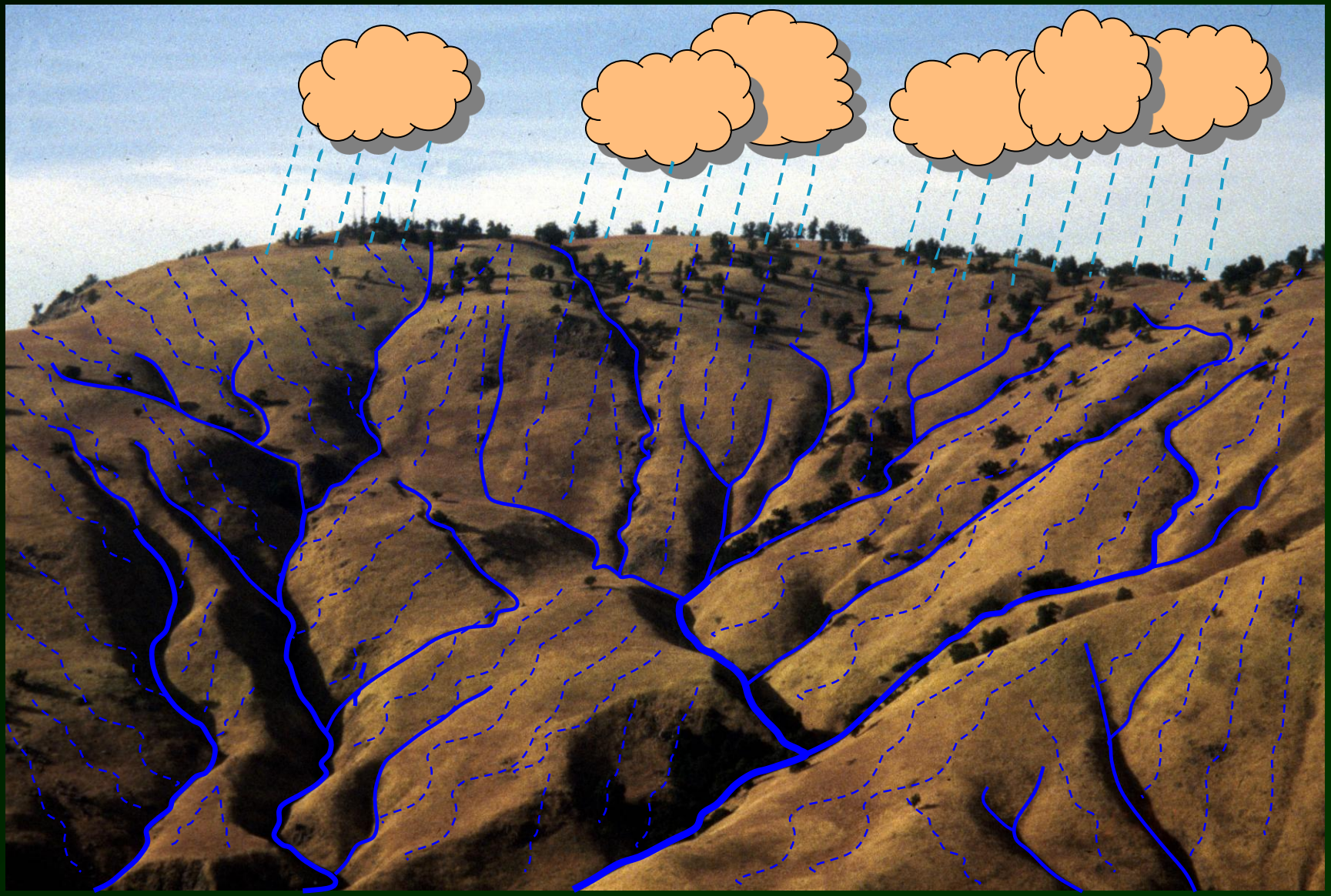
Course Objectives

- Understand the Hydrologic Influences of Trail Alignments
- Learn the Process for Laying Out and Flagging Trails
- Understand the Layout Criteria for Designed Control Points
- Learn how to Determine the Maximum Sustainable Linear Grade
- Learn how to Determine Linear Grades Between Control Points
- Learn Flagging Between Control Points (Segmenting)

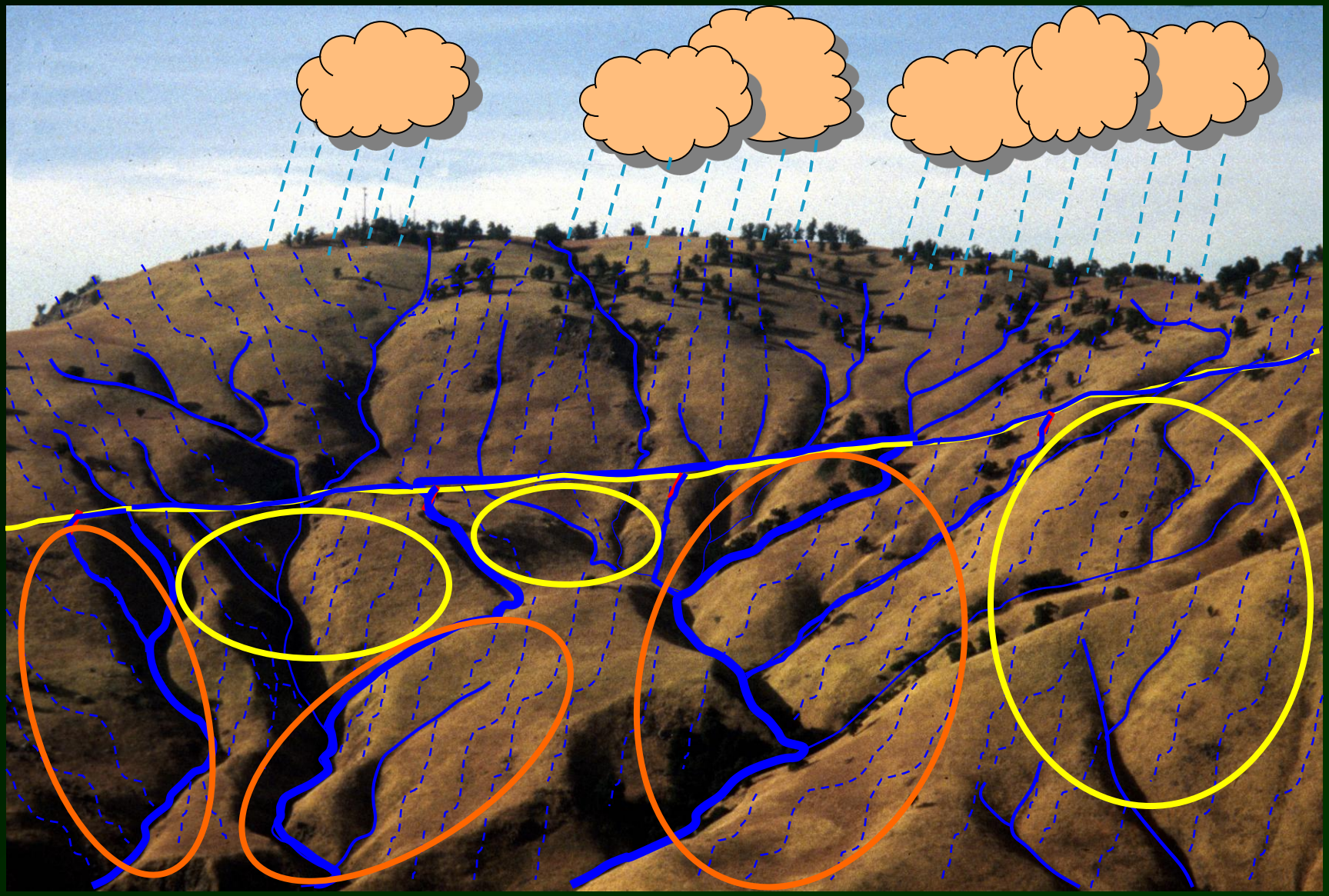
Trail Layout Concepts and Process

Water is the Most Influential Factor in Designing and Laying Out Trails

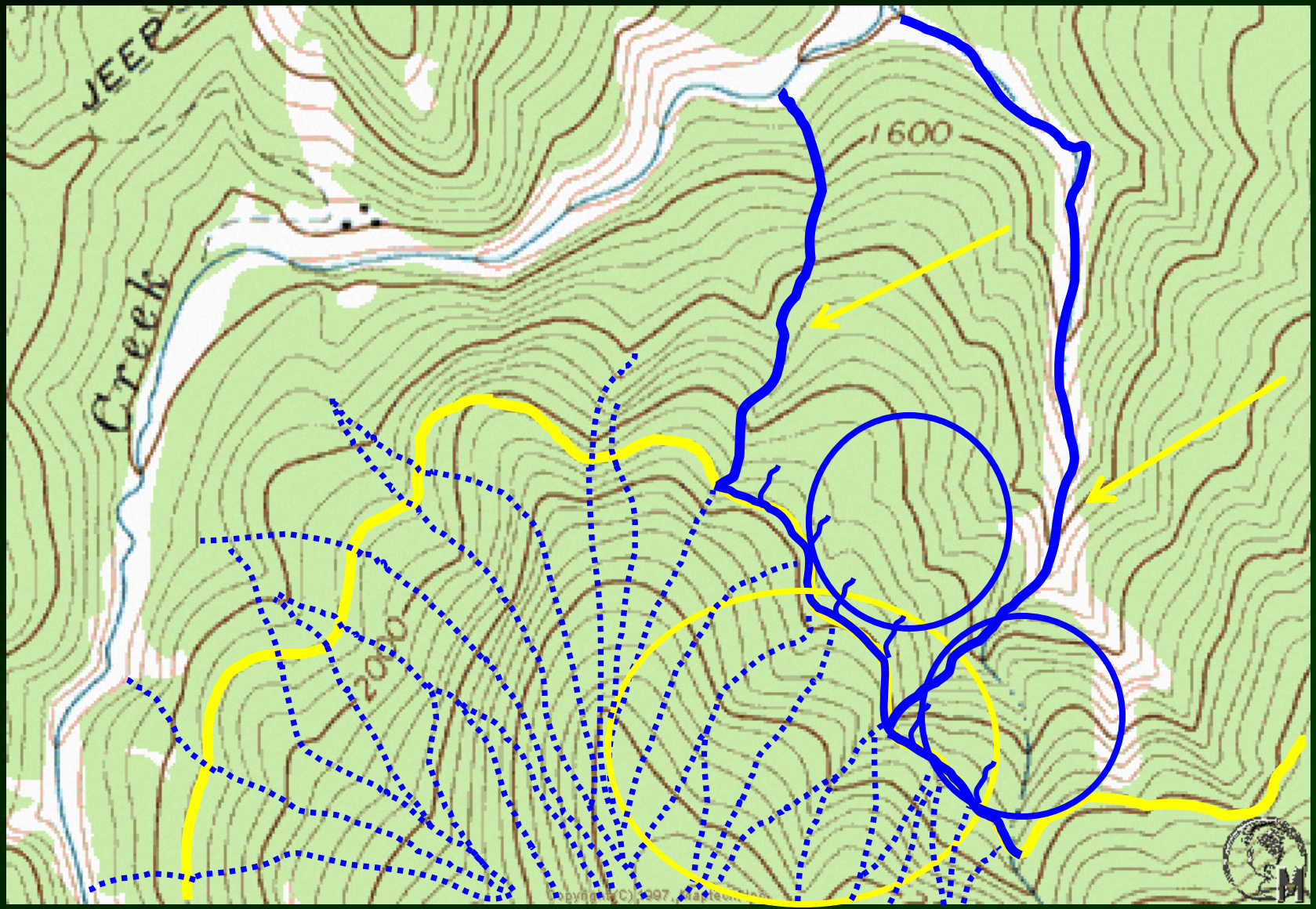
Natural Runoff Patterns



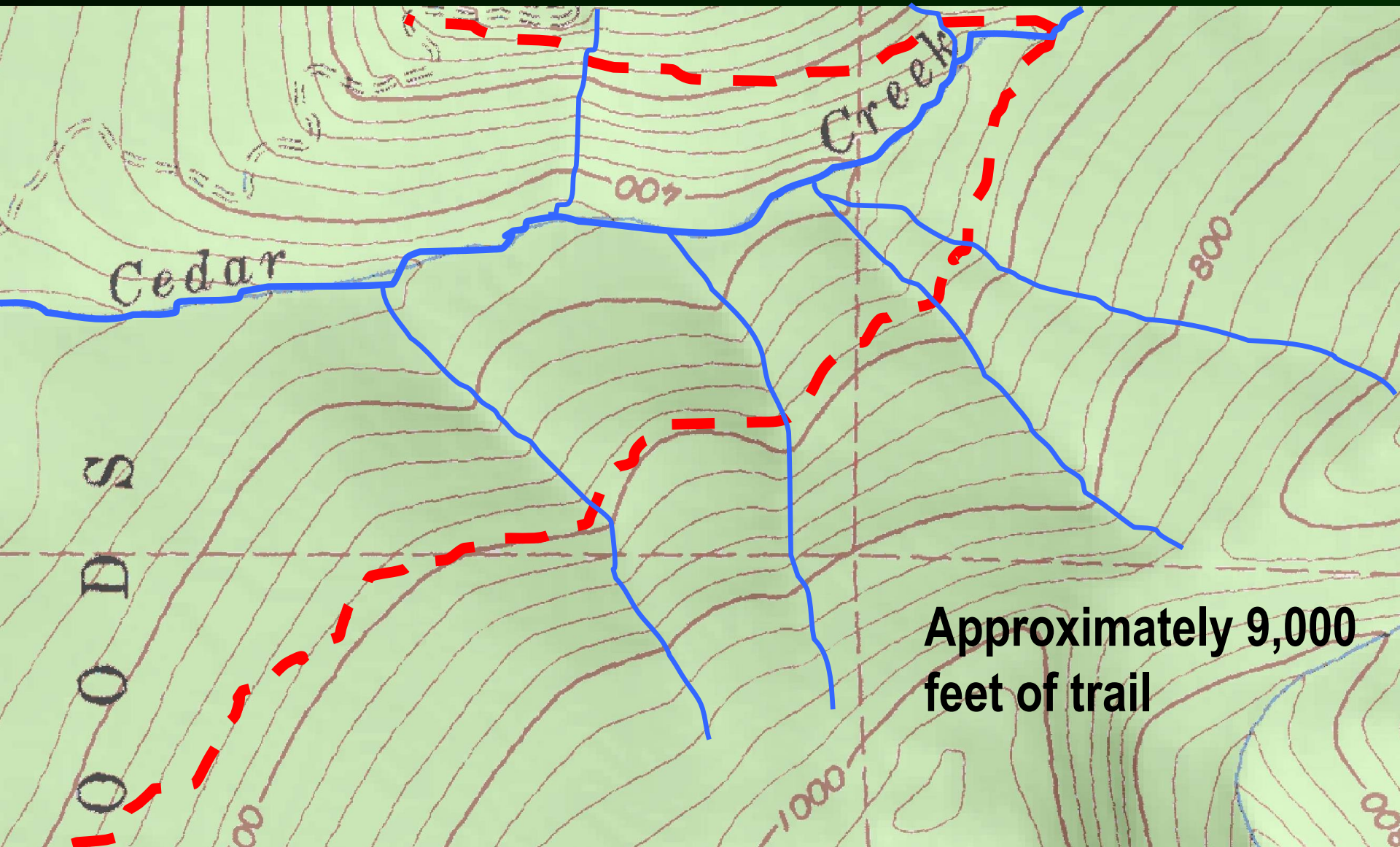
Modified Runoff Pattern



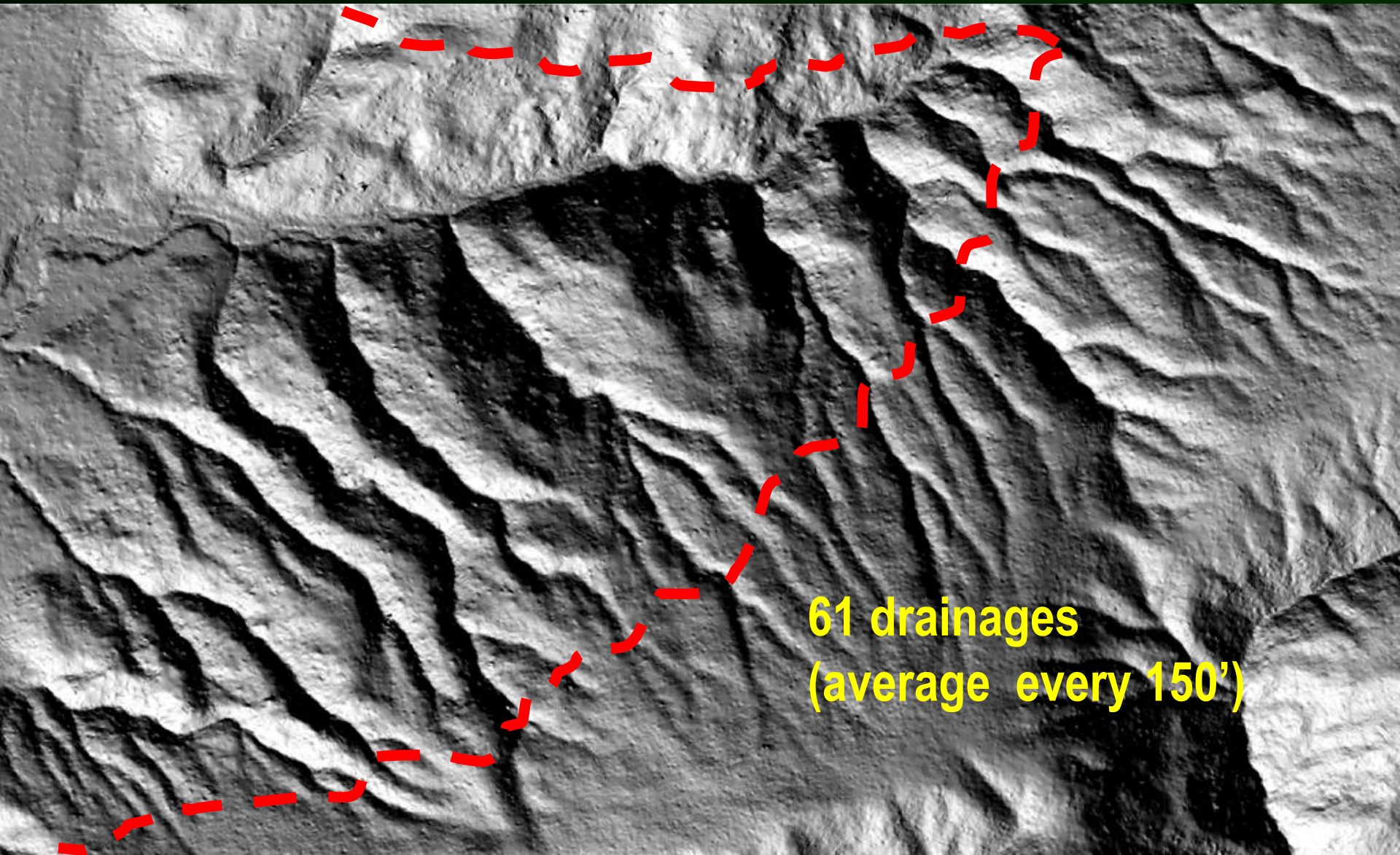
Interception and Diversion of Sheetflow



Interception and Diversion of Ephemeral Drainages

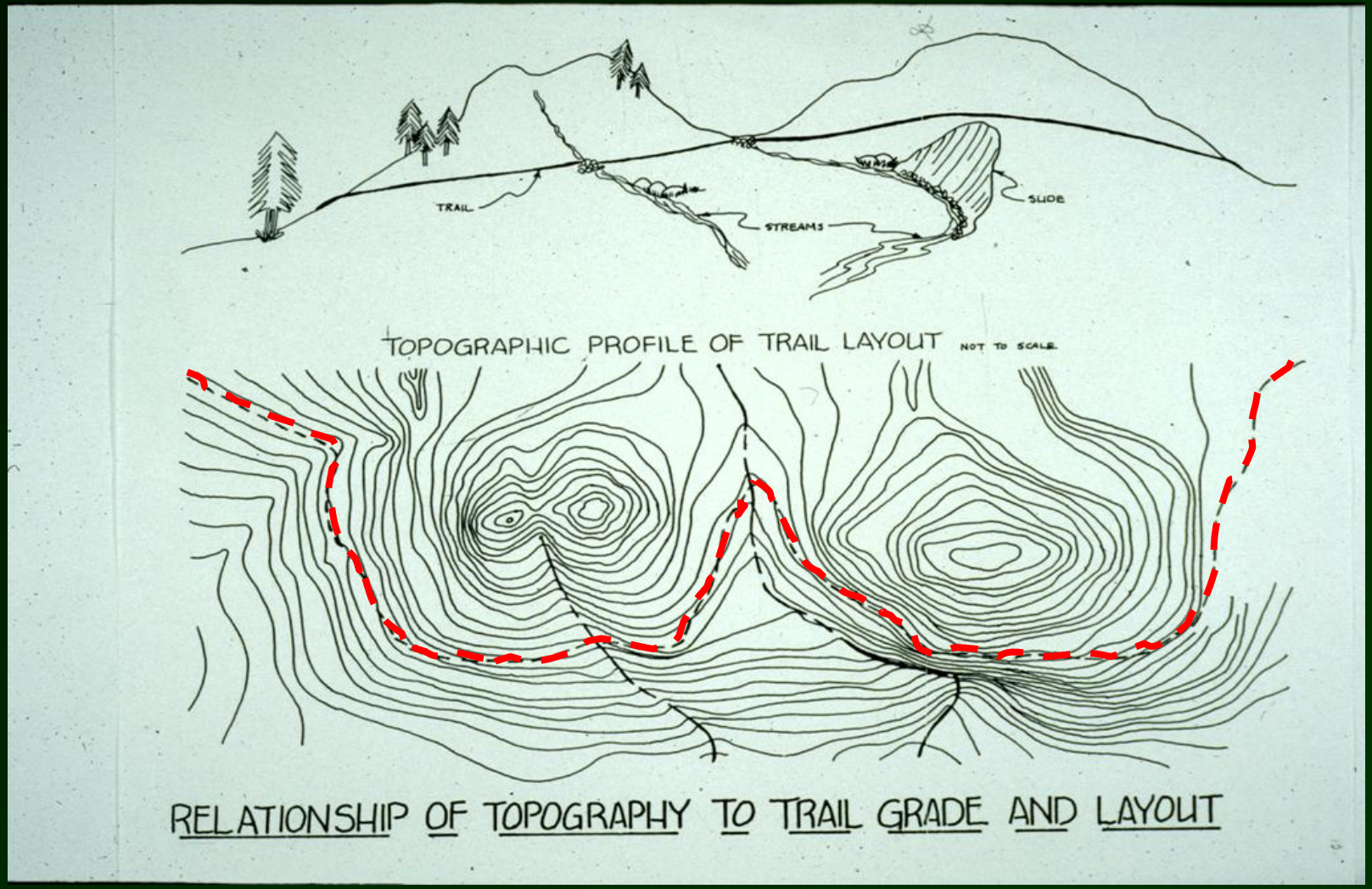


Interception and Diversion of Ephemeral Drainages



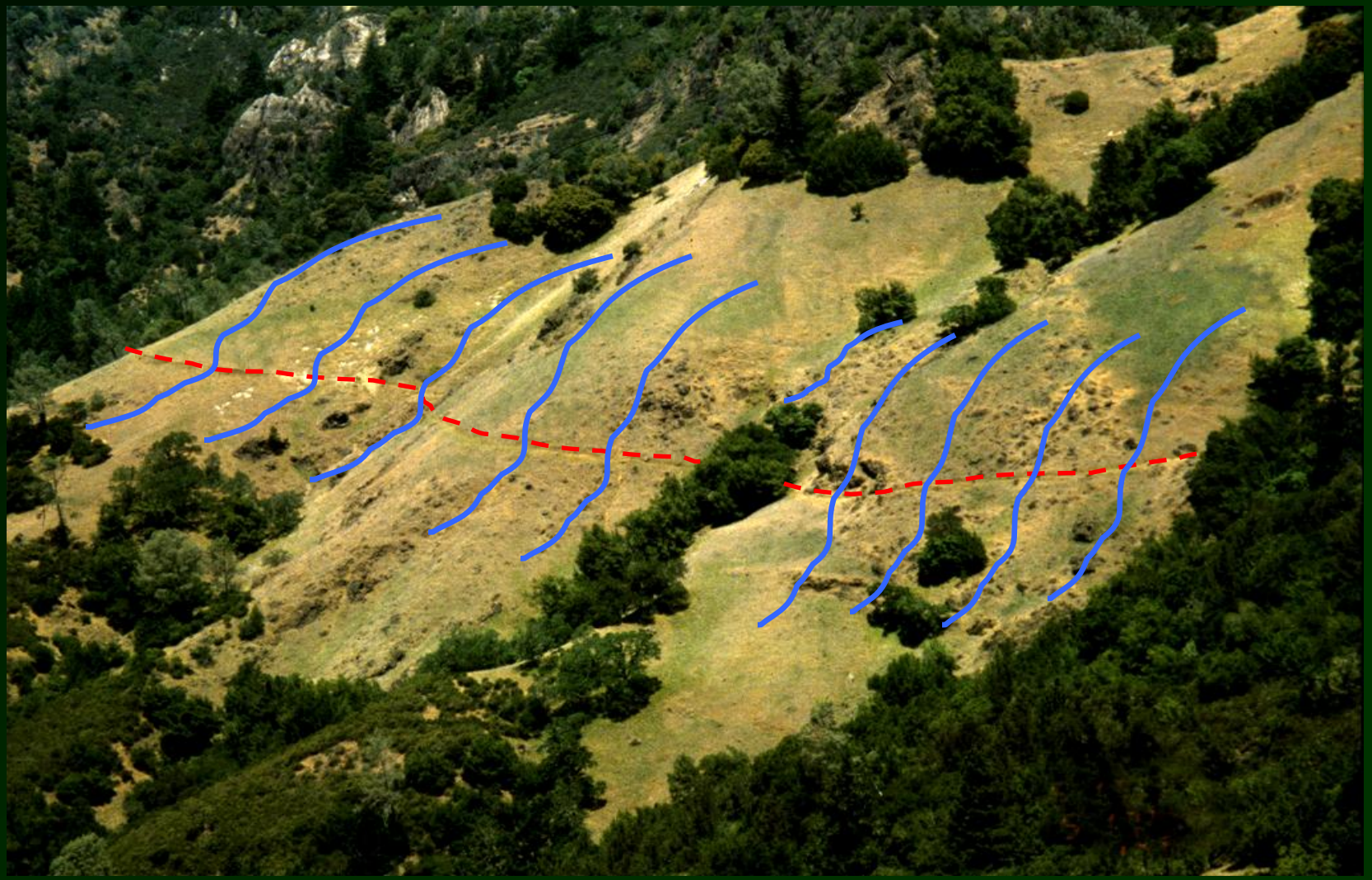
As Water Accumulates It Gains Volume and Energy and Becomes an Erosive Force

Laying Out Trails Following the Contour of the Land Helps Facilitate Natural Sheet Drainage

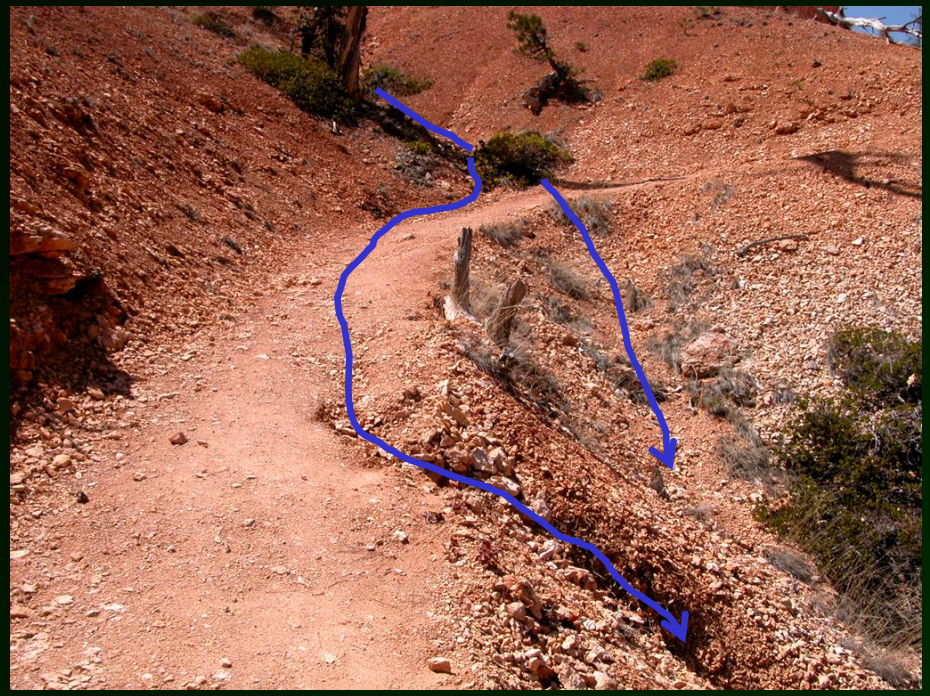


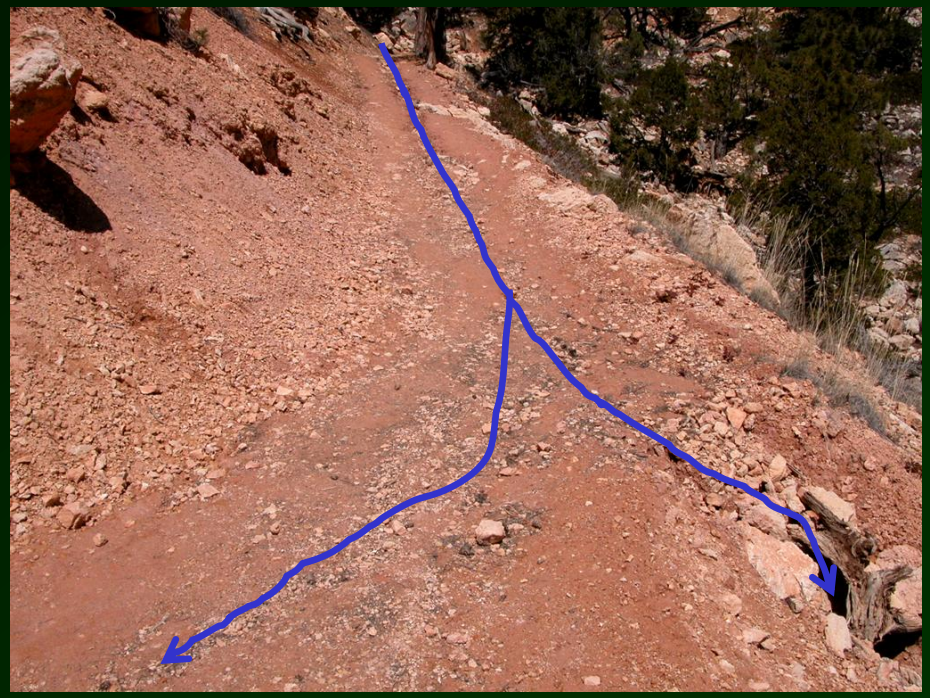
This Layout Process Is Called Curvilinear Alignment (Crossing Contour Lines at Flat or Oblique Angles)

Curvilinear Layout Helps Keep the Trail Alignment Perpendicular to Natural Sheet Runoff



Following the Contours of the Land Alone is not Sufficient for a Sustainable Trail

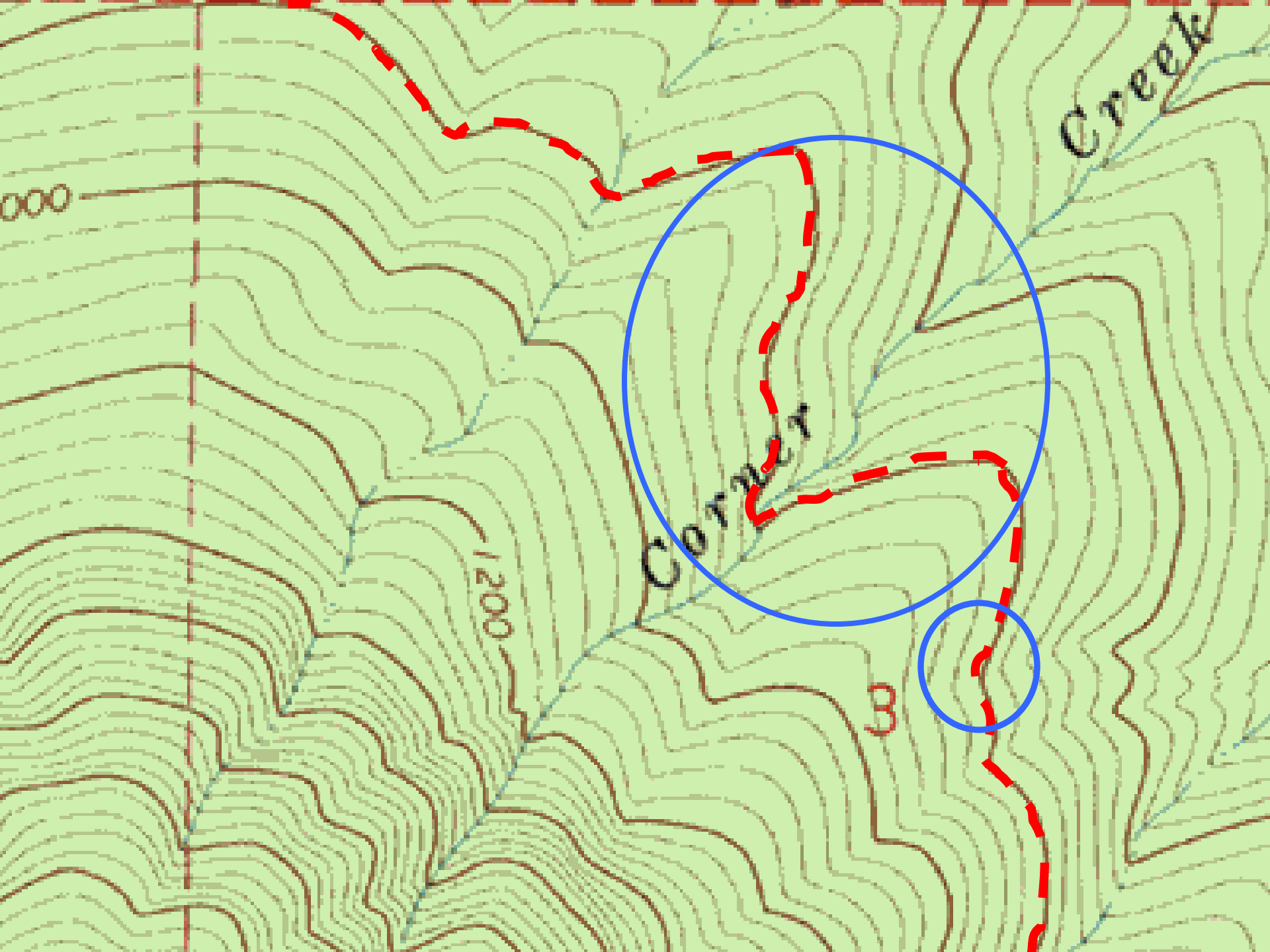




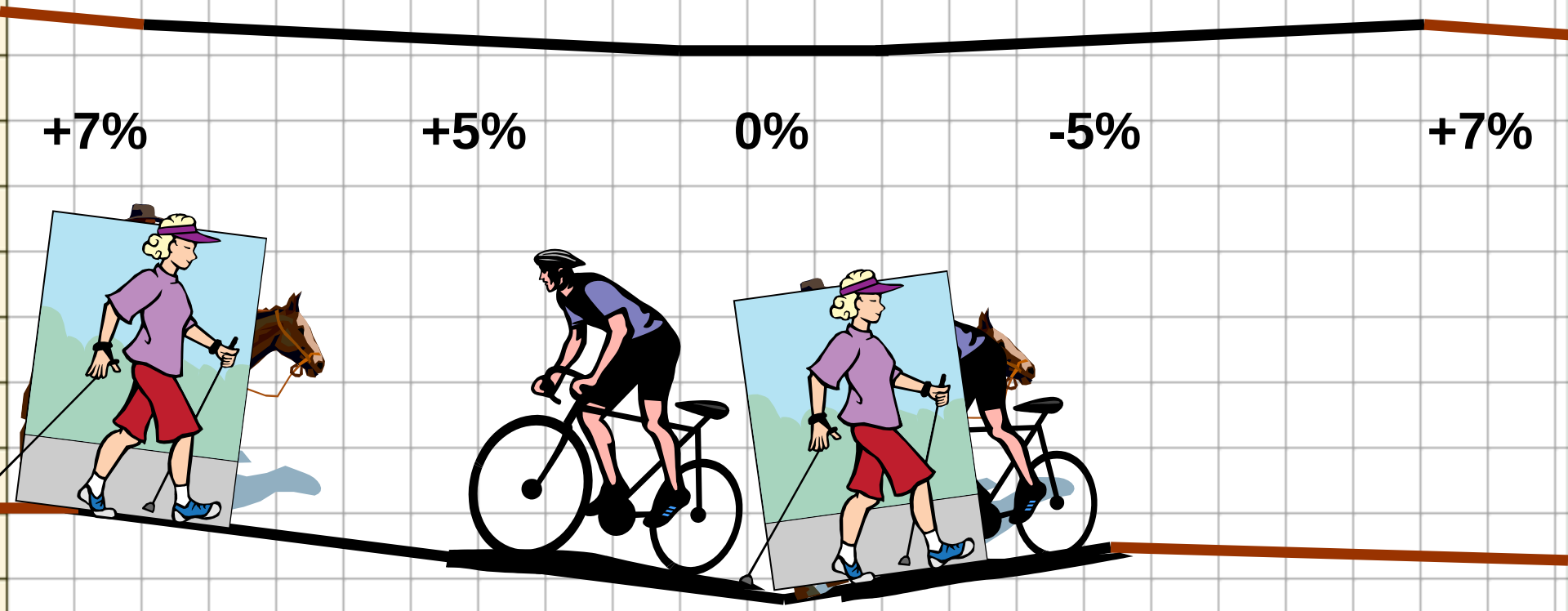
Gradually drop down
into and climb out of
all drainages

Pull up and in on all drainage crossings

Including Small Swales

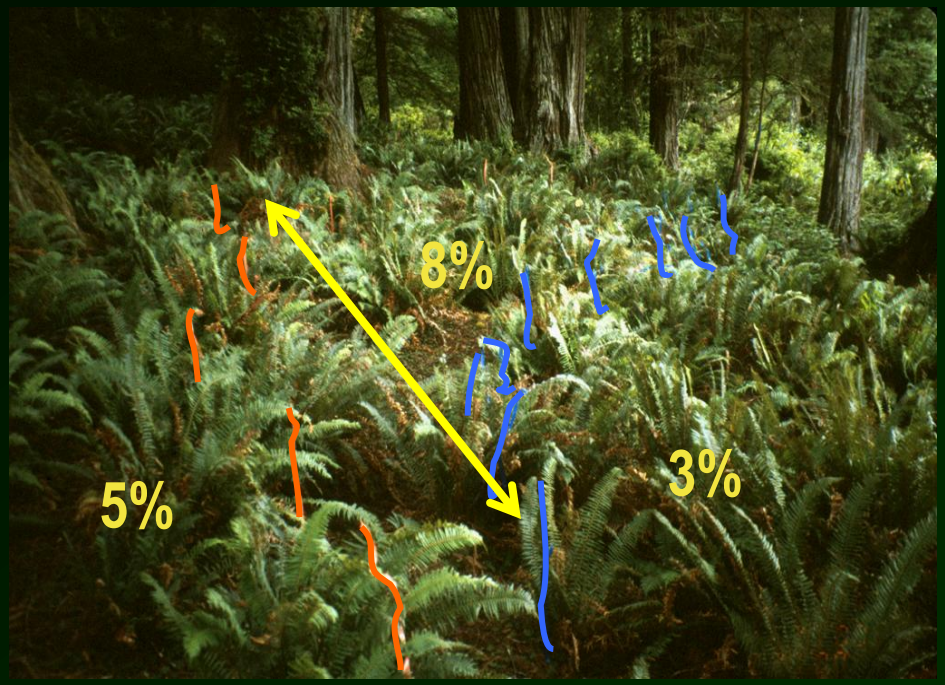

Creek
Corral
1200
3

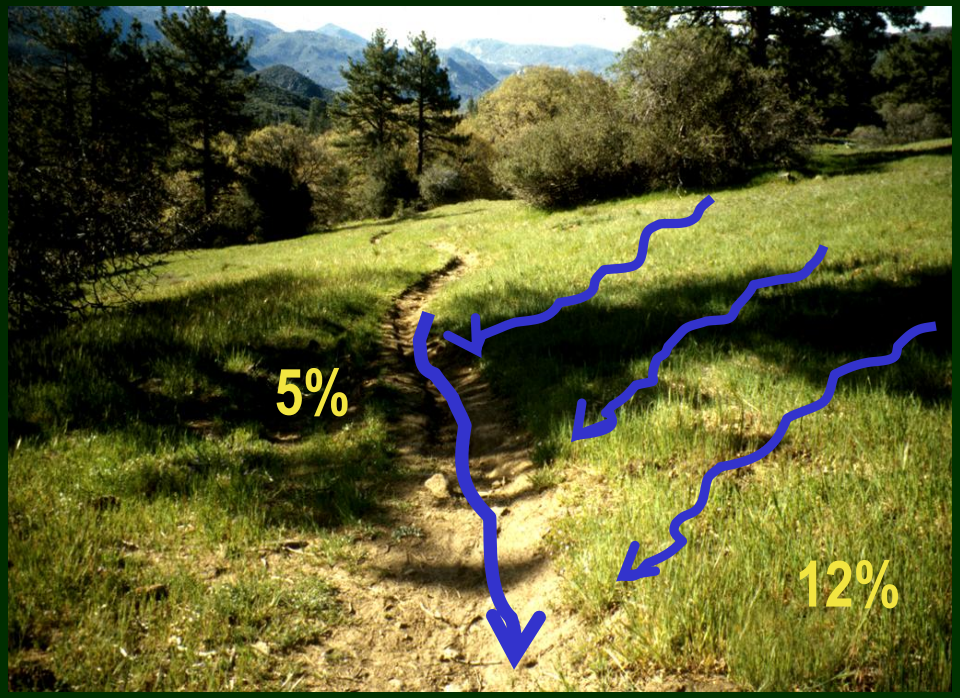
Drain Swale



Grade Reversal

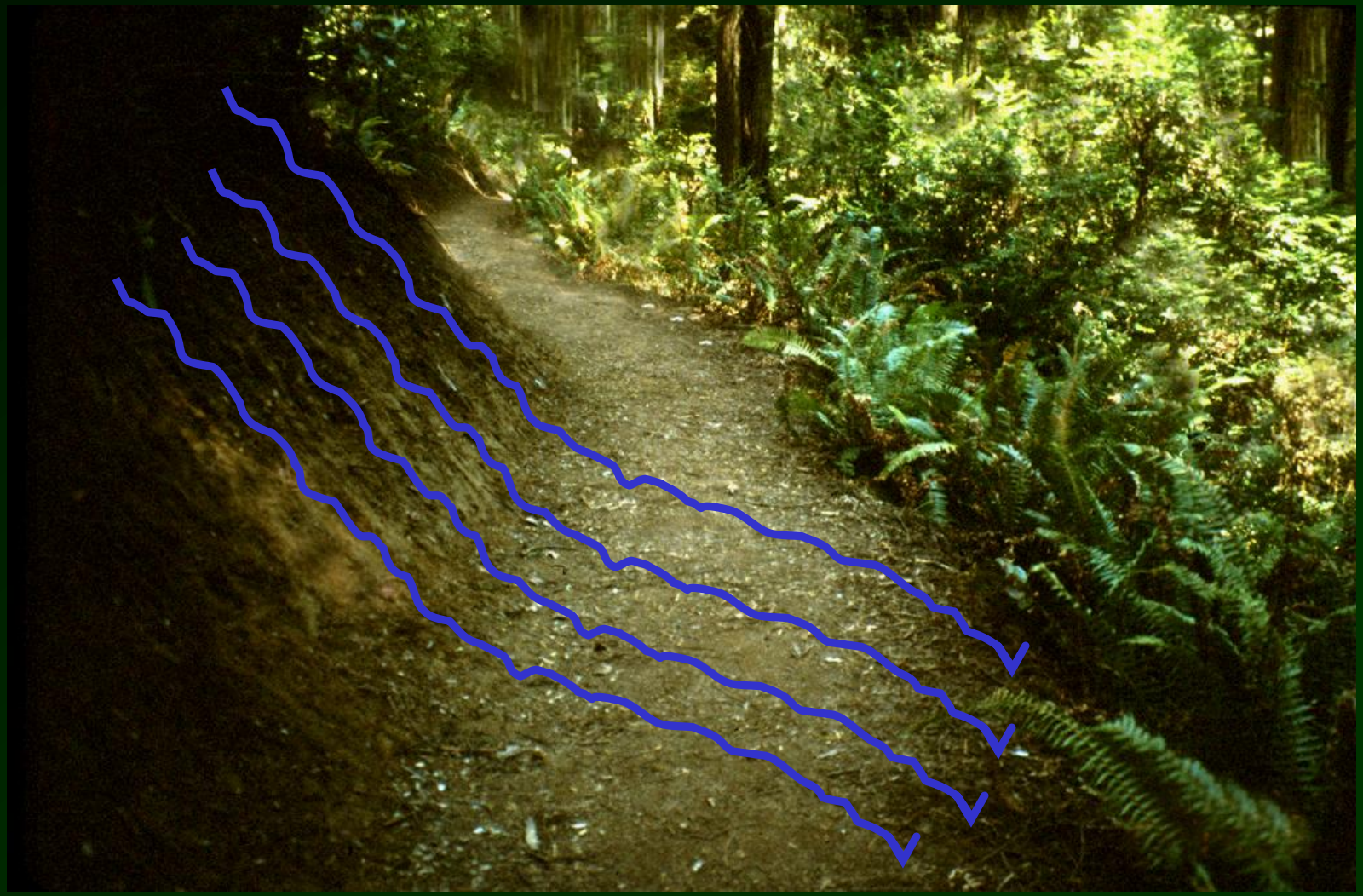
Monitor the Hill Slope for a Change in Grade and Adjust Linear Grade According to site Conditions



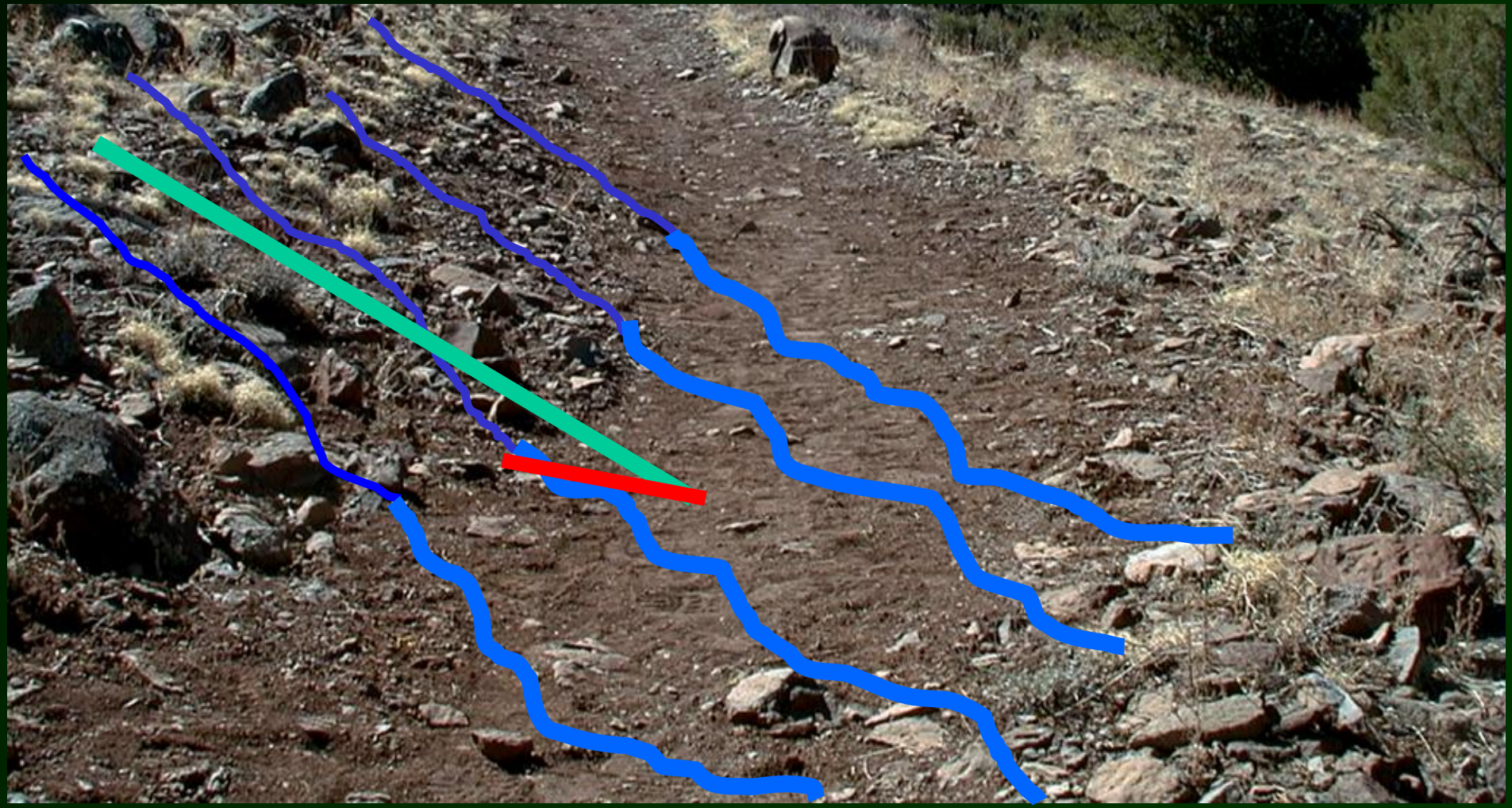


Curvilinear Layout Requires Closely Following the Landform Pulling in and out of all Swales and Crenulations

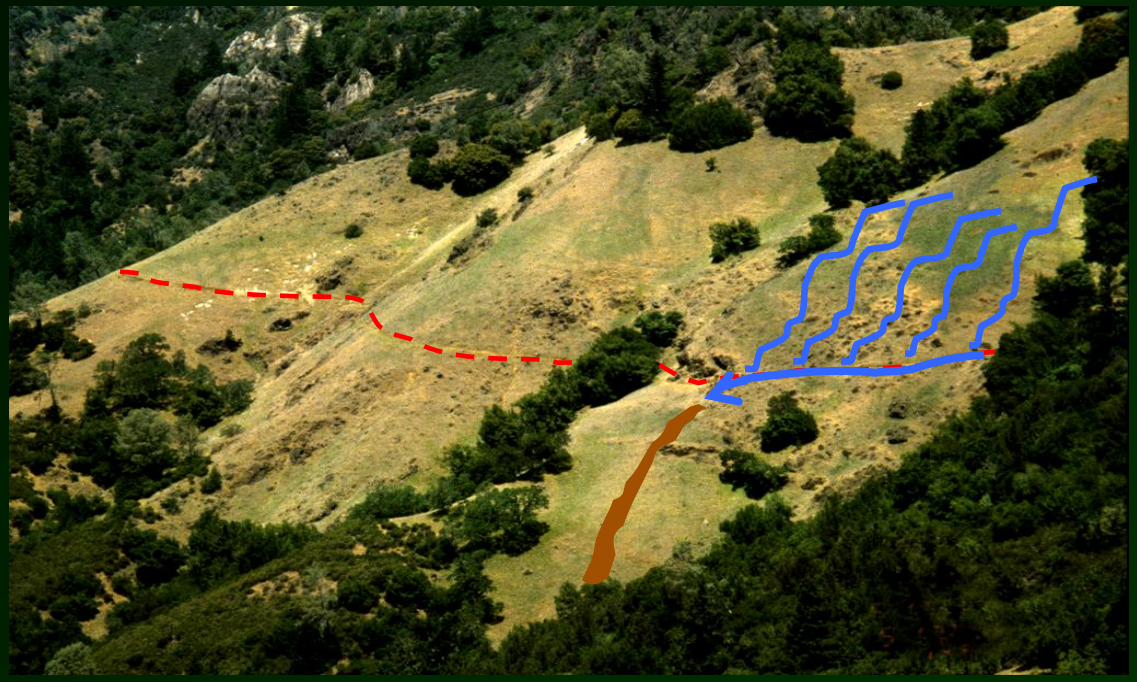
Curvilinear Layout Combined With Hillside Construction and Outsloping Prevents Water Diversions and Accumulation



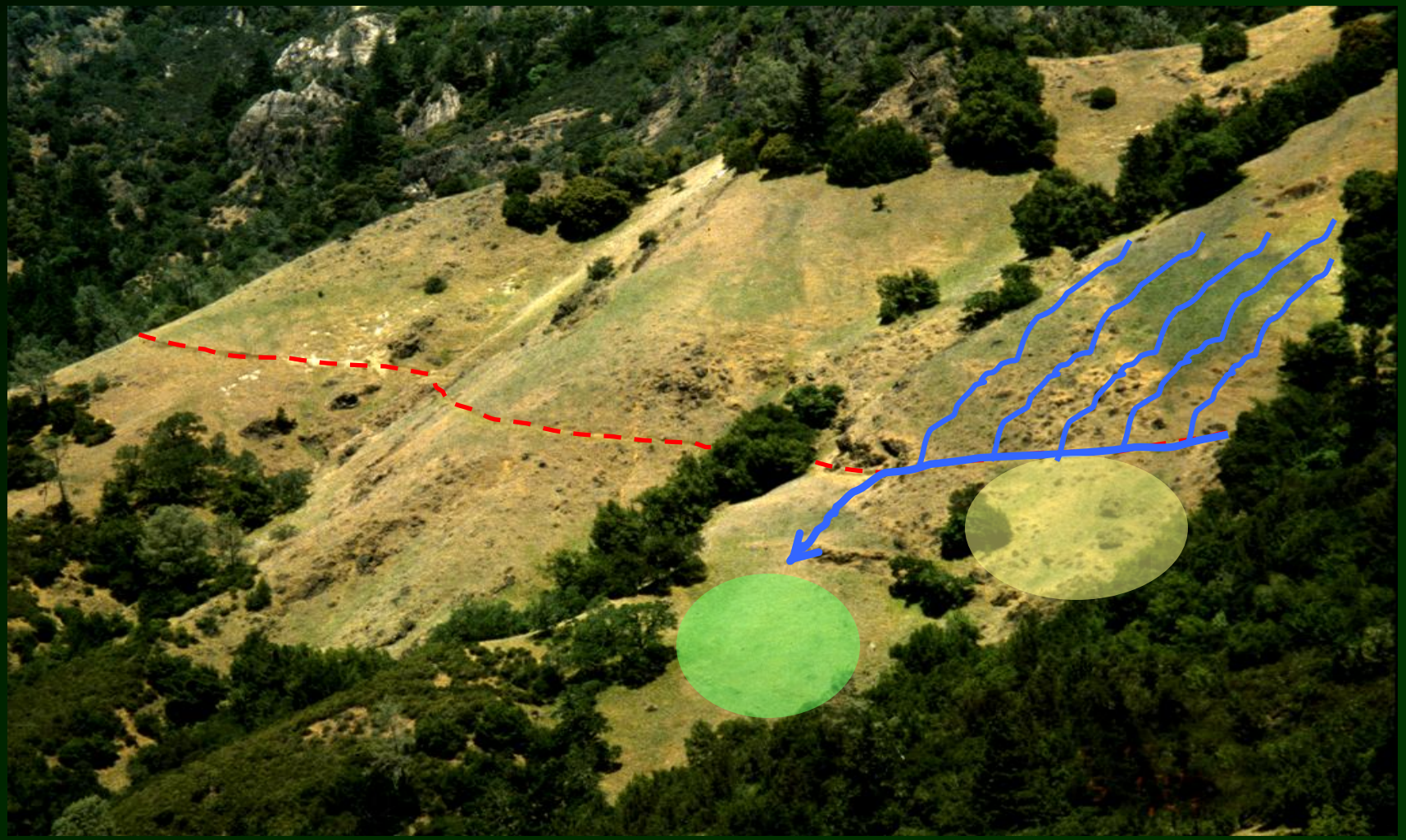
Trails on Gentle Side Slopes With Quarter to Half Bench Sheet Runoff less Efficiently



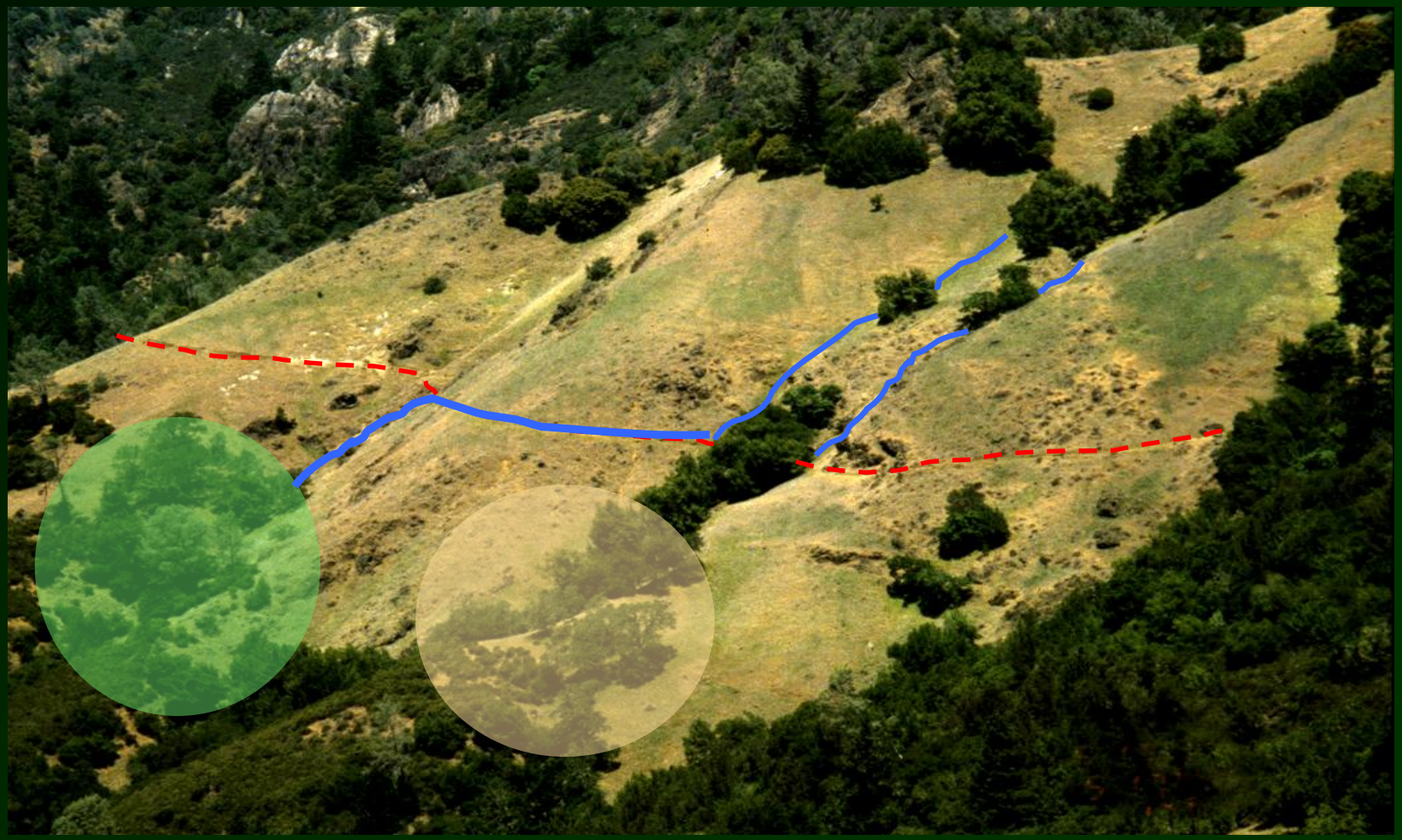
When Water Is Accumulated on the Trail and Arbitrarily Drained Off It Also Creates Erosion Below the Drain Point



These Drainage Designs can also Affect the Vegetation and Wildlife Communities Below by Changing the Amount of Water they Receive

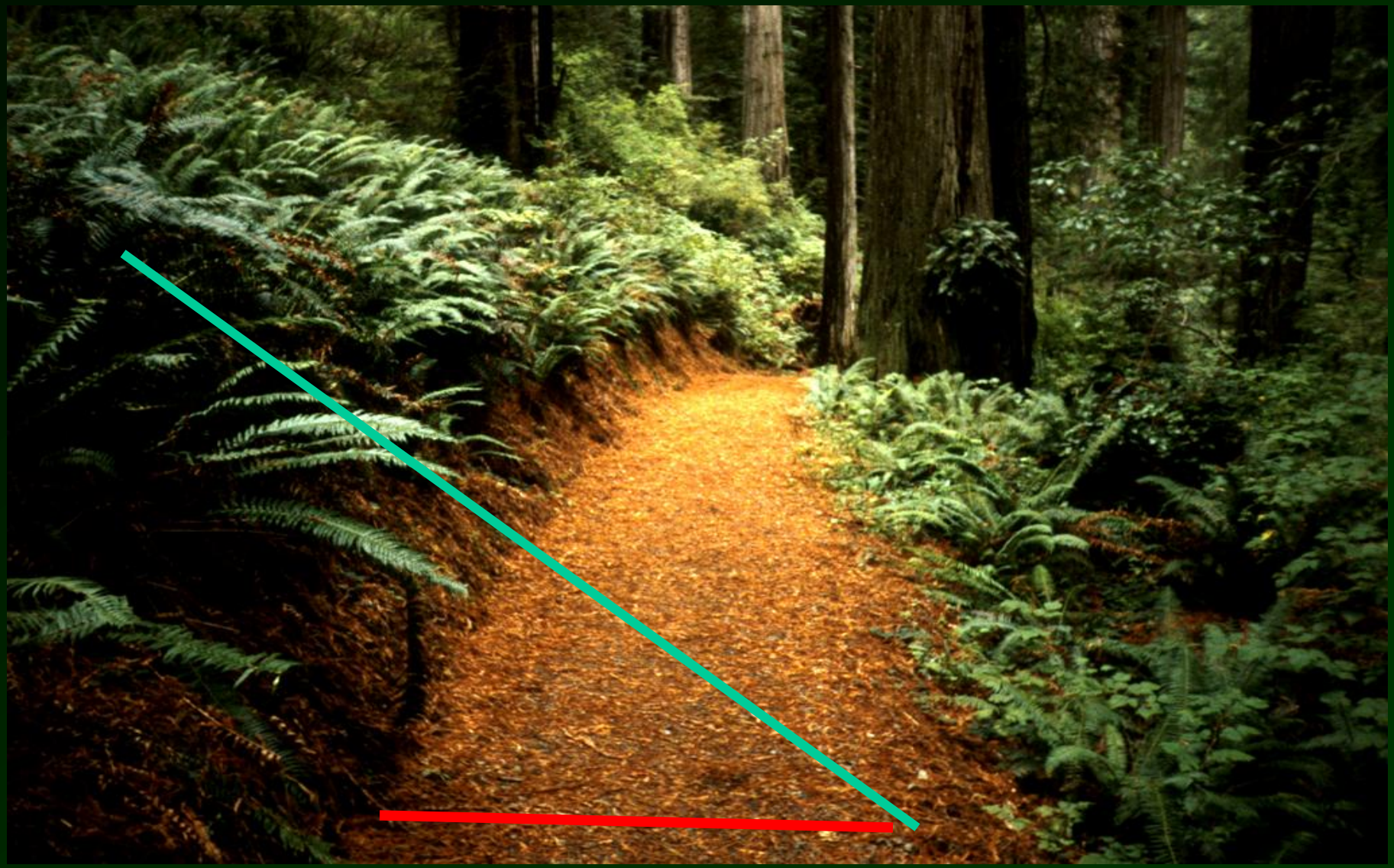


The Worst Diversions Result in the Coupling of two Drainages Together, Causing the Dewatering of one and the Destabilization of the Other



Layout Trails on Hill Sides to Provide a Fuller Native Bench

Fuller Trail Benches Facilitate a Stable and Durable Trail Tread Surface



When Possible Layout Trail Alignments Above Trees to Reduce Resource Impacts and Trail Structures

Retaining Walls are Usually Required When the Trail Passes Under a Large Tree

Retaining the Landform's Natural Drainage Patterns Is the Key to Sustainable Trails

Prior To Laying Out a Trail the Design Standards and Maximum Sustainable Linear Grades Must be Identified

What is a sustainable linear grade?

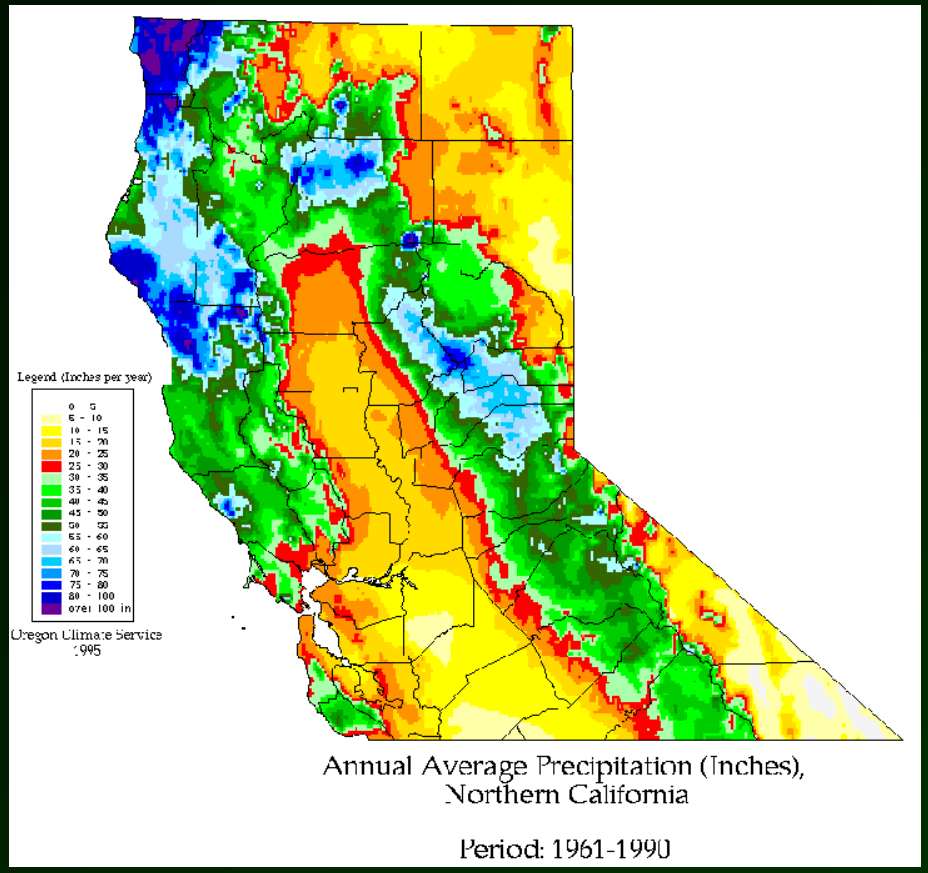
- Linear grades where the trail tread will retain its designed shape and function while only receiving routine cyclic maintenance
- This assumes that the trail is properly designed, laid out, constructed and maintained

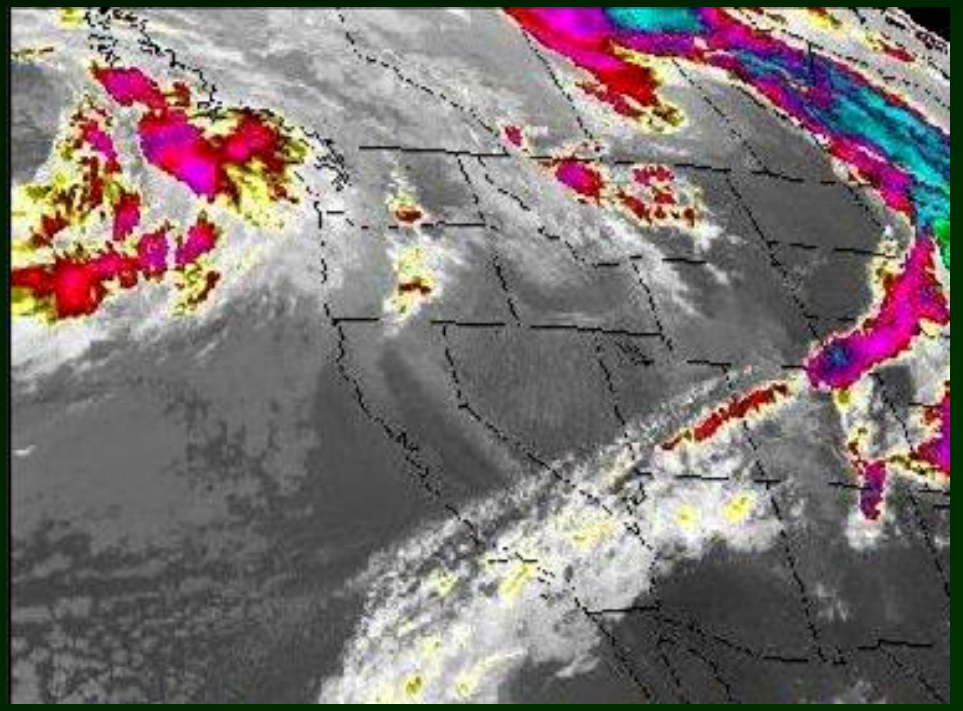
Accessibility

User Groups & Level of Use

Soil Strength and Durability

Annual Rainfall





Rainfall Intensity

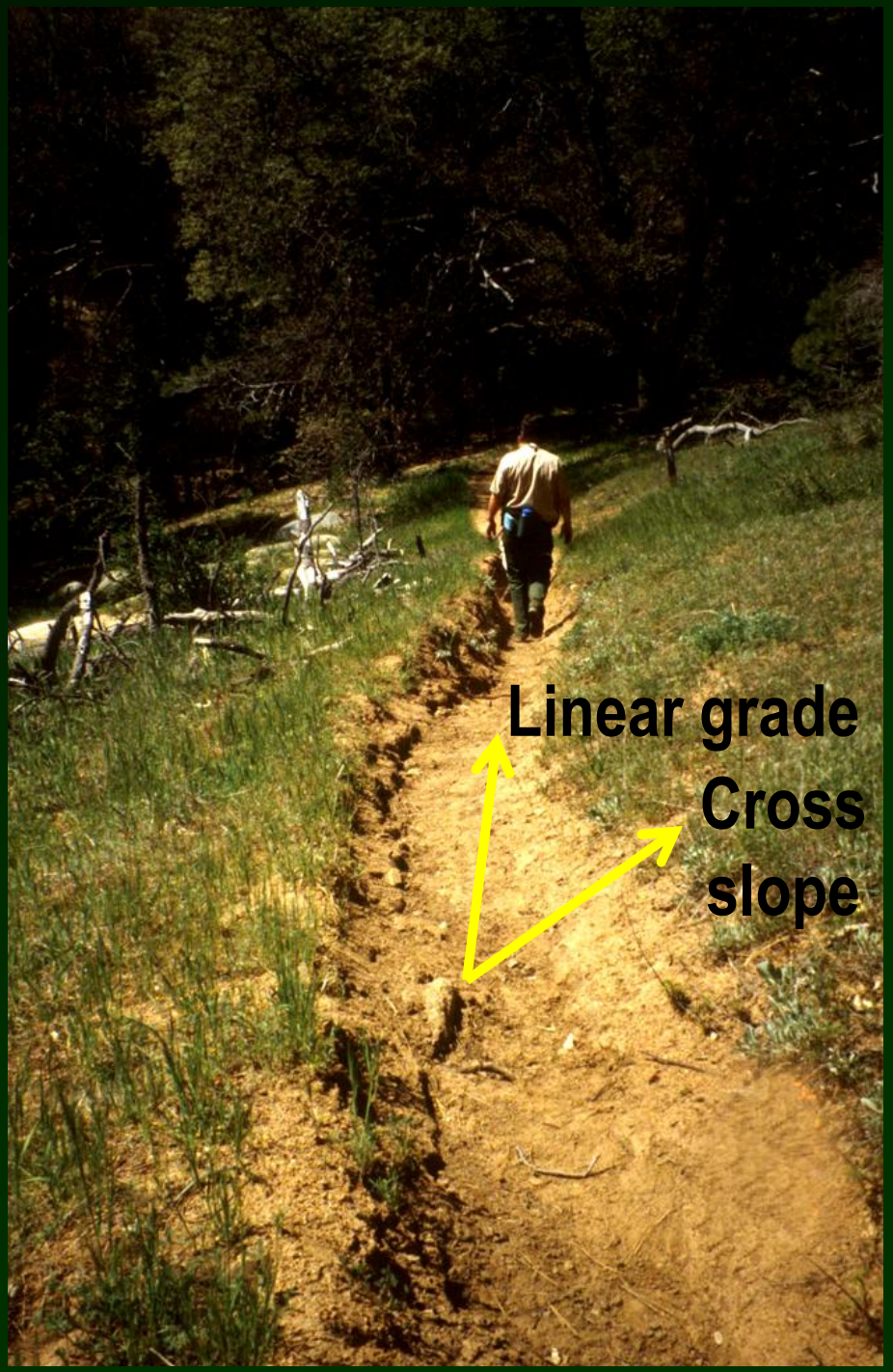
Canopy Cover

Location on the Hillslope

Season of Use

Percent of Hillslope

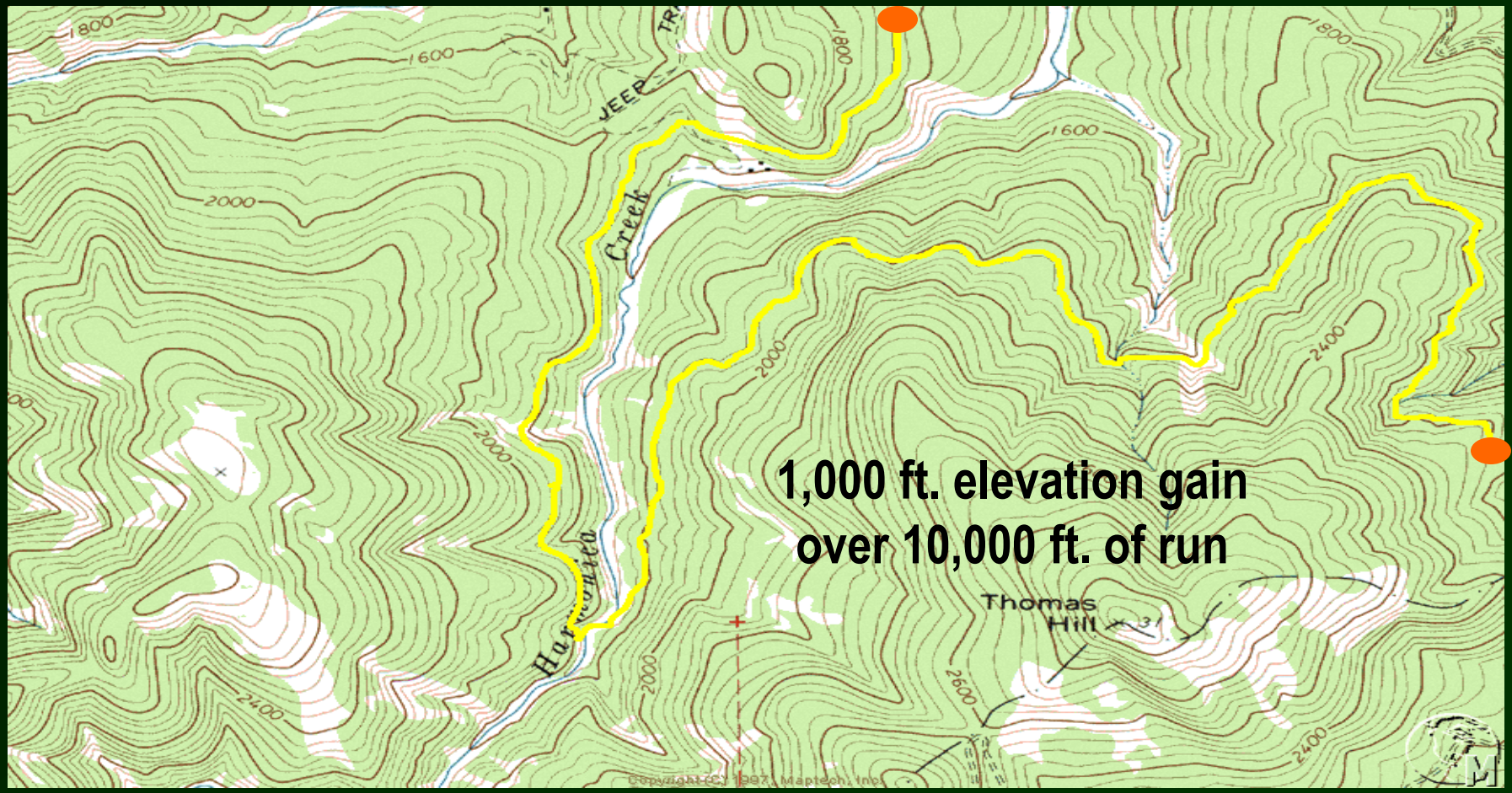
- User groups
- Amount of use
- Soil strength & Durability
- Annual rainfall
- Rainfall intensity
- Canopy cover
- Location on the hillslope
- Season of use



Evaluation of Existing Trails

The Maximum Sustainable Linear Grades are Determined by Reconnaissance and Planning Efforts

Once the Maximum Sustainable Linear Grade Is Established It can be Compared to the Average Grade Between the Major Control Points



The Elevation Difference Between the Two Major Control Points Is Divided by the Linear Distance Between the Two Points to Determine the Average Grade : Example 1,000 Ft. of Elevation Divided by 10,000 Ft. of Linear Run = a 10% Average Grade. If the Maximum grade is 8% then you Divide 1000 ft by .08 = 12,500 of trail length or an additional 2,500 ft of trail

The Average Linear Grade Is Used When Identifying Minor Control Points During Reconnaissance

During Reconnaissance the Trail Corridor can be Roughly Located by using a Clinometer and Shooting at Objects at Your own eye Level

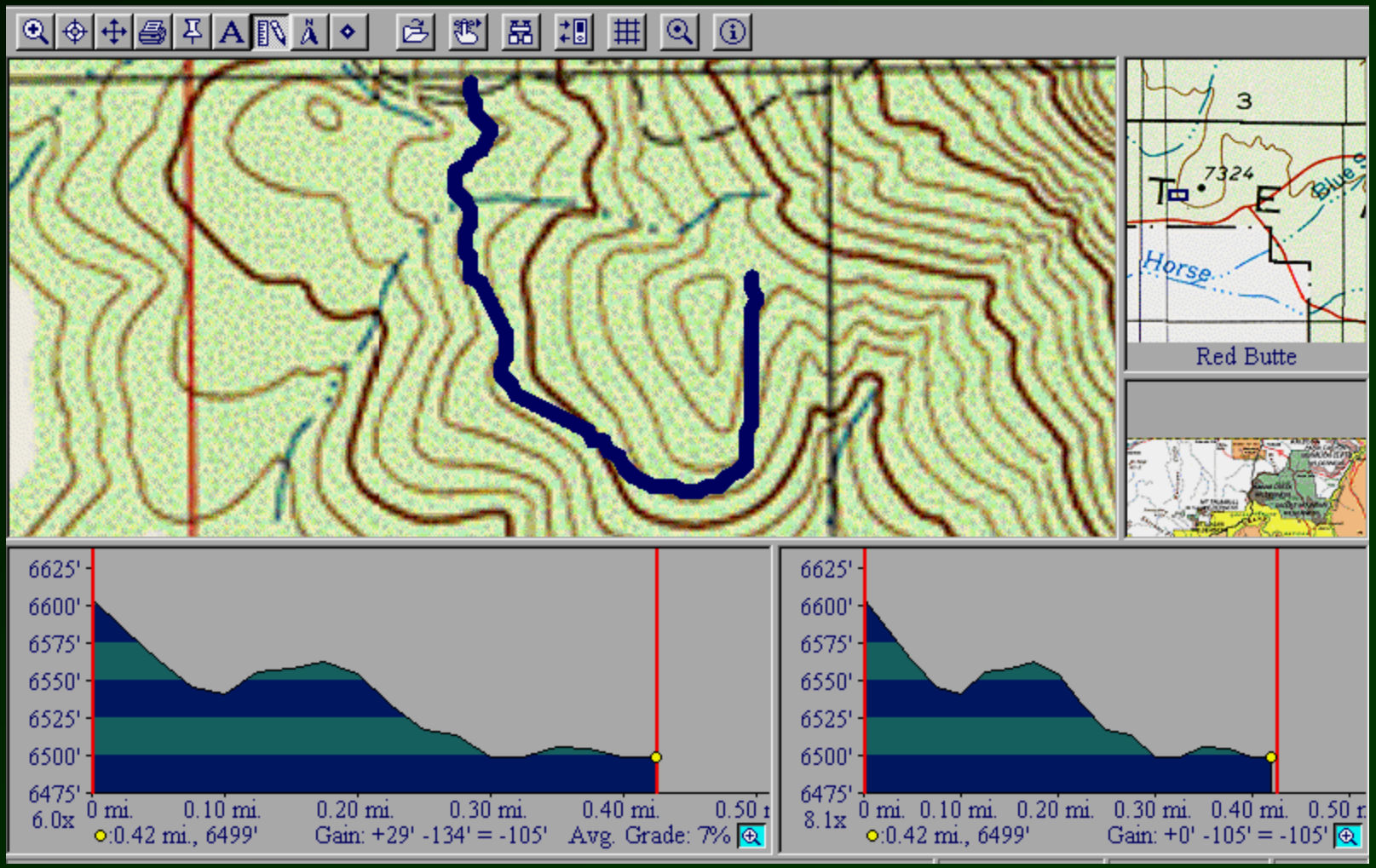
To Check the Accuracy of Your Shot Locate an Object Next to Where you are Standing and Locate your eye Level

Once you Reach the Object you Shot at, Shoot back at the Known Location of your eye Level to Check Your Accuracy

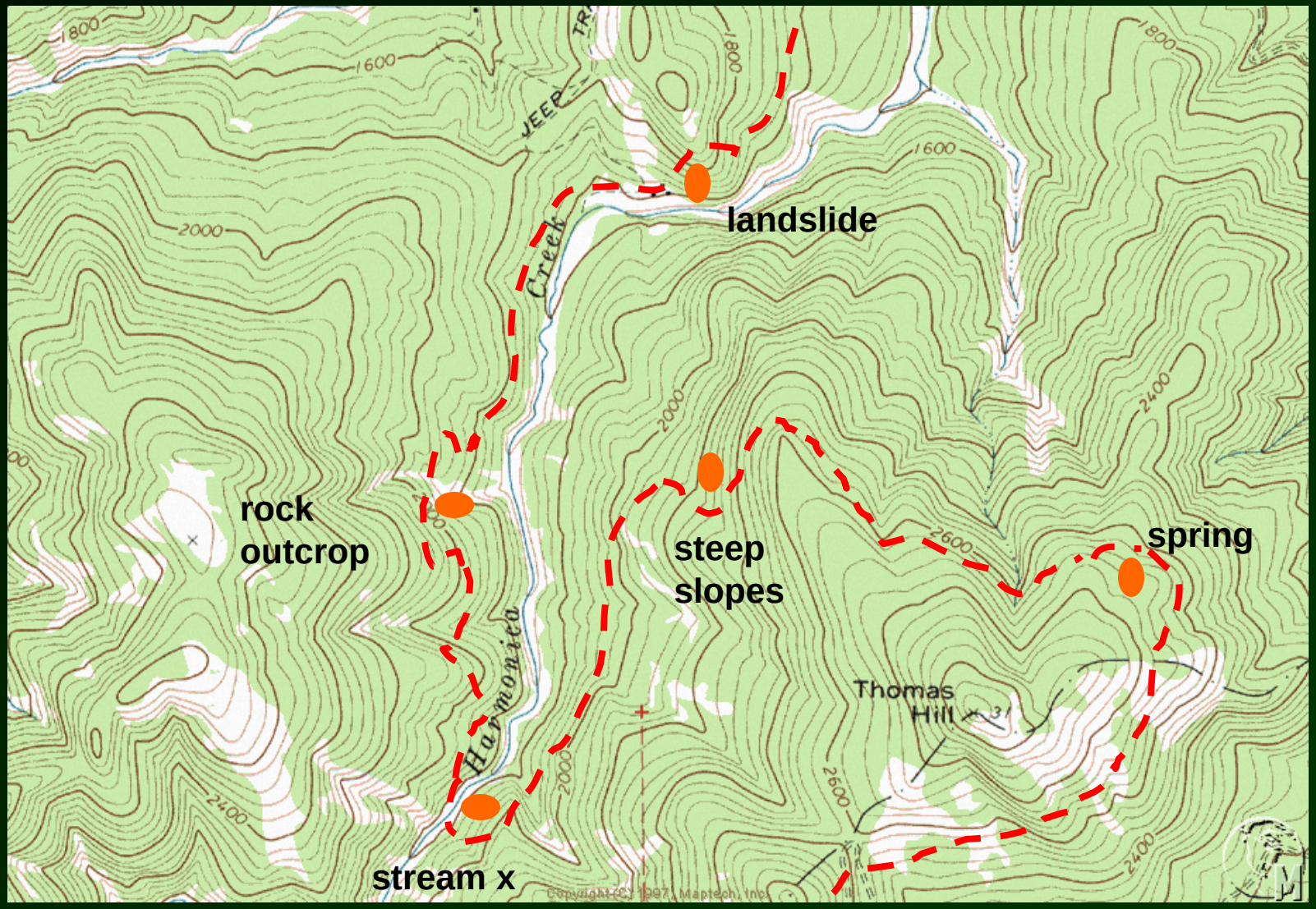
Elevations can be Taken with an Altimeter at each Control Point to Determine Elevation Differences

Control Point Locations and Elevations are Plotted on a Topographic Map or GPS Unit

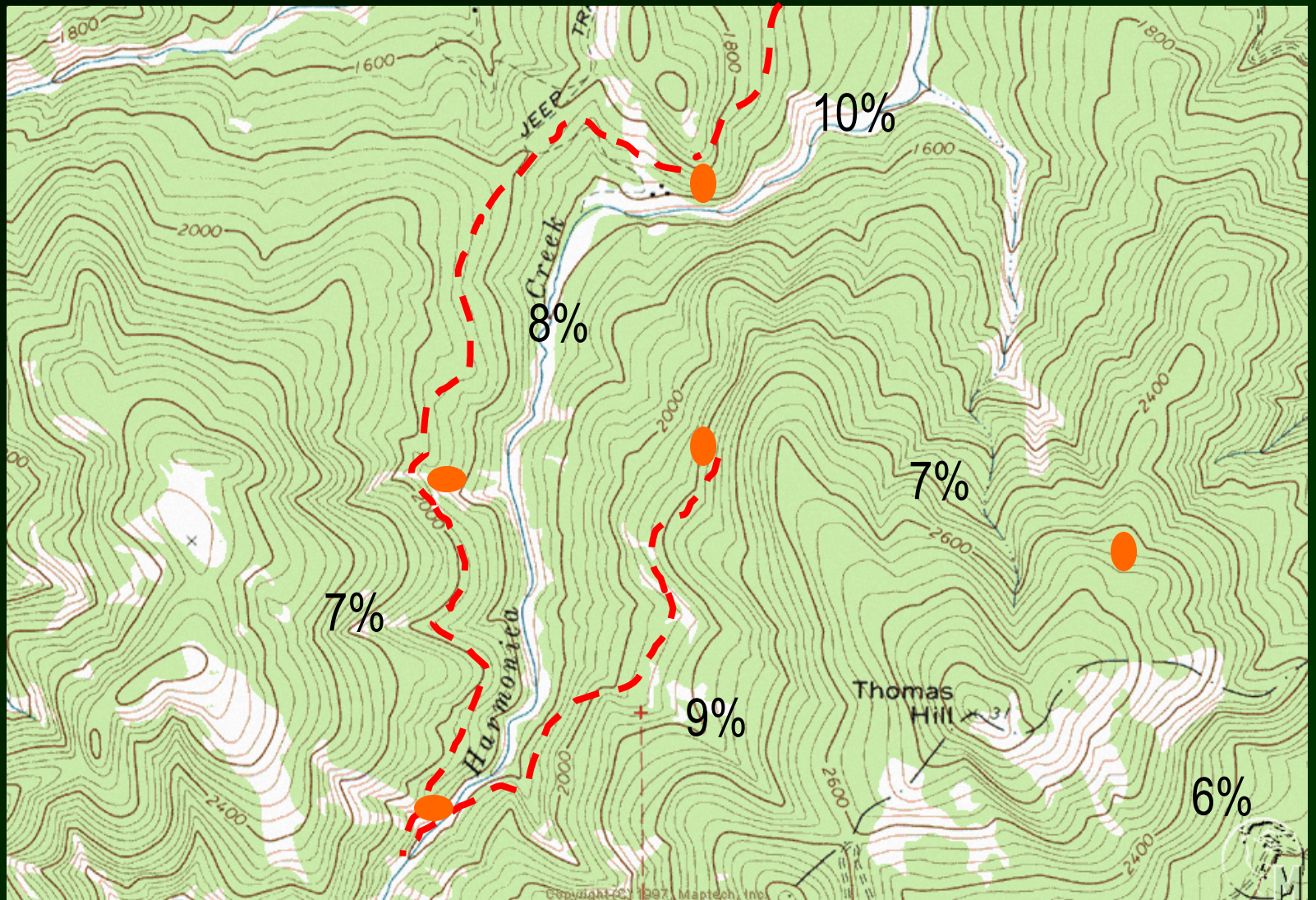
Control Points can also be Plotted on Electronic Maps to Determine the Elevation, Distance and Grade Between the Various Control Points



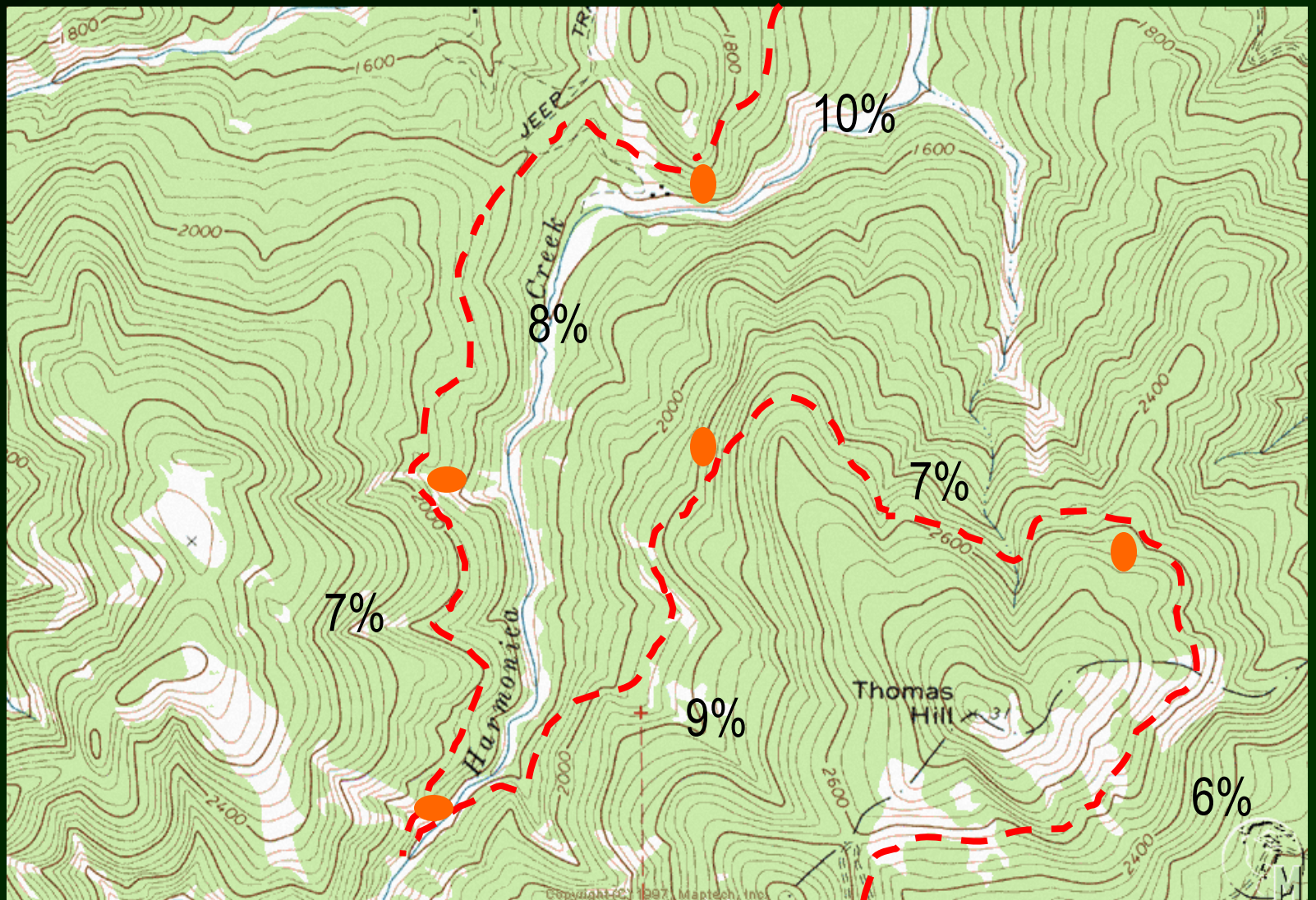
Traditional Linear or Blind Flagging Often Results in Unwanted Grade Adjustments

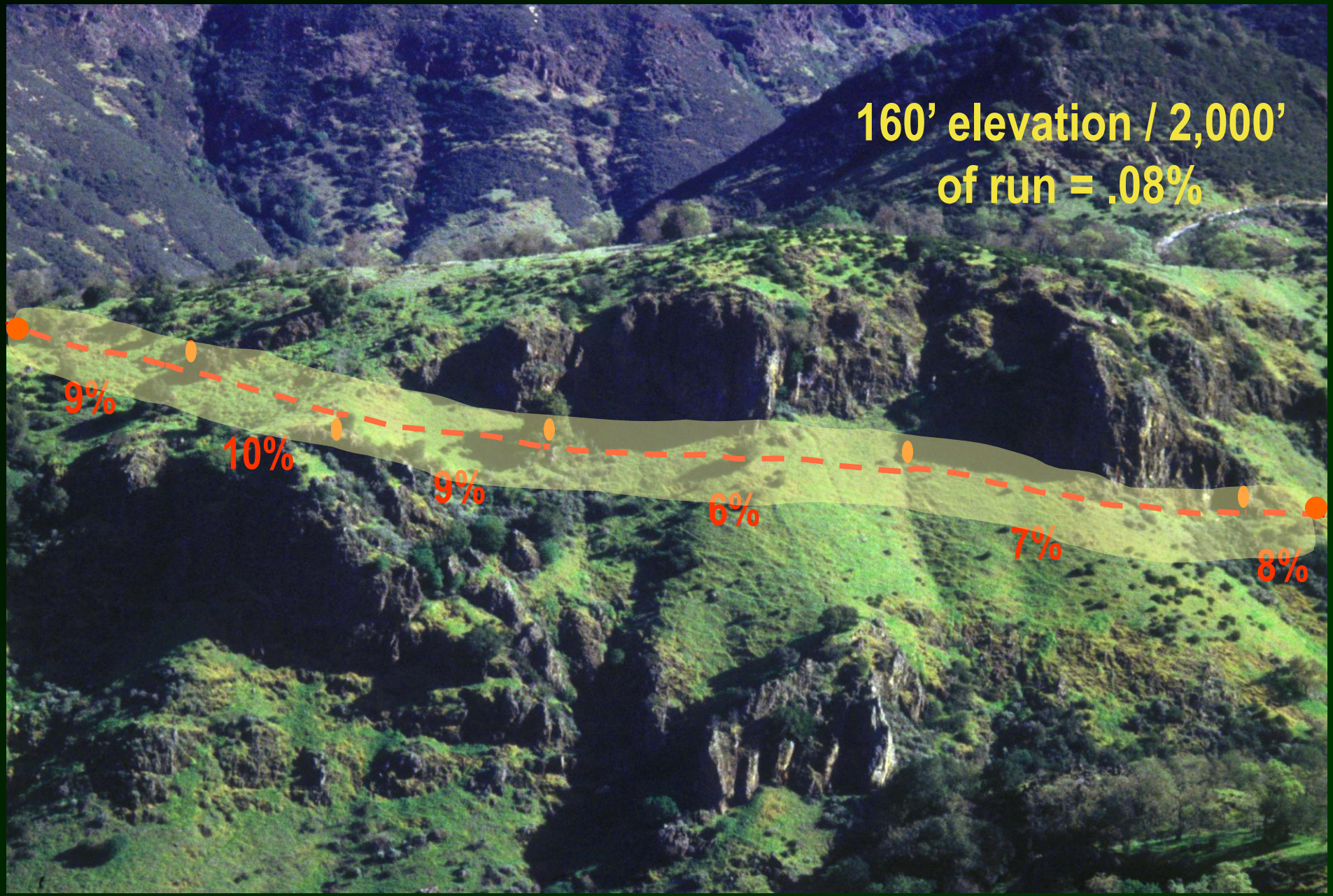


Layout is Performed Between Control Points to Eliminate Abrupt Grade Changes

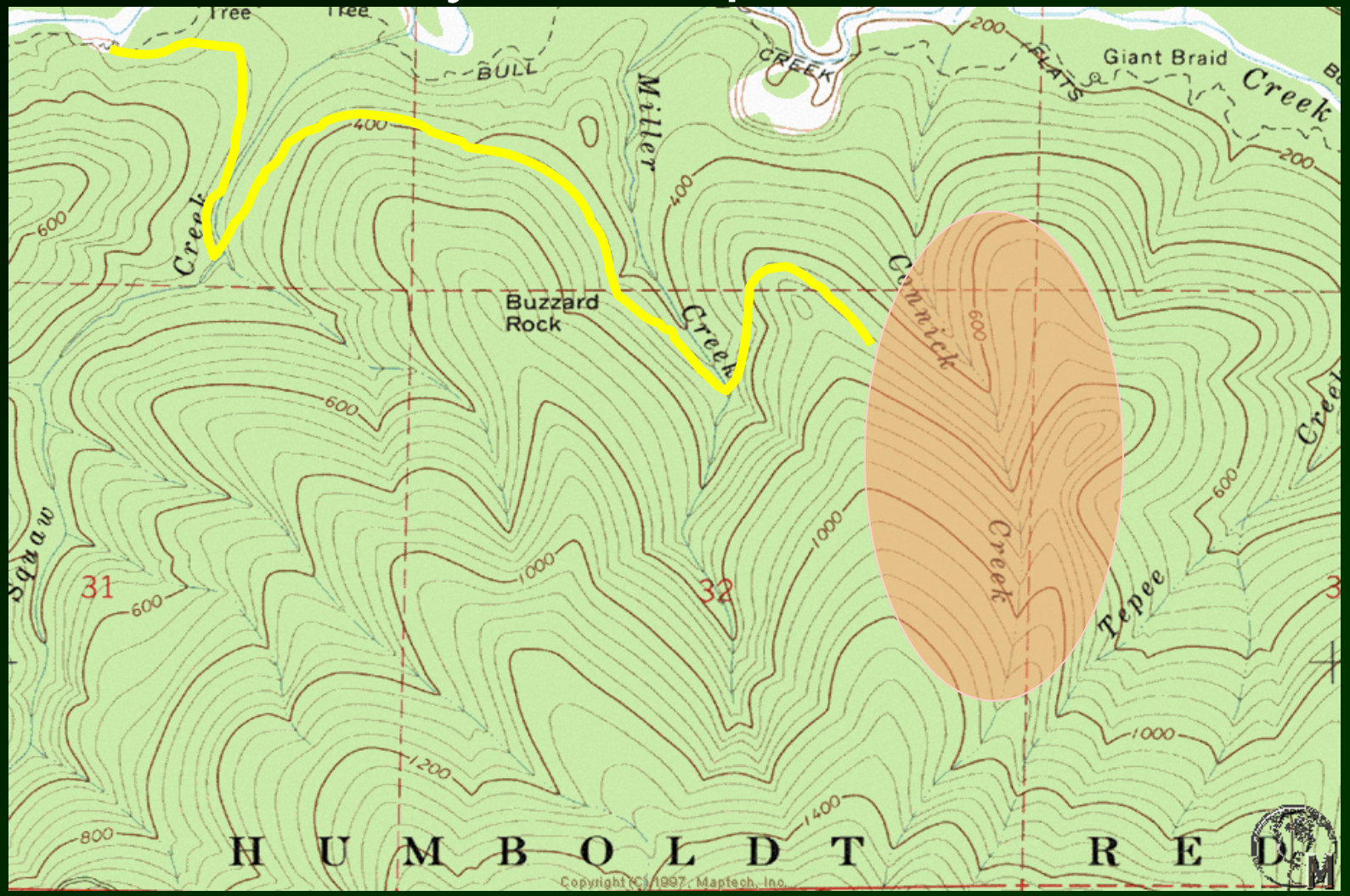


Flagging From two Control Points Back Towards the Center is an Effective Method

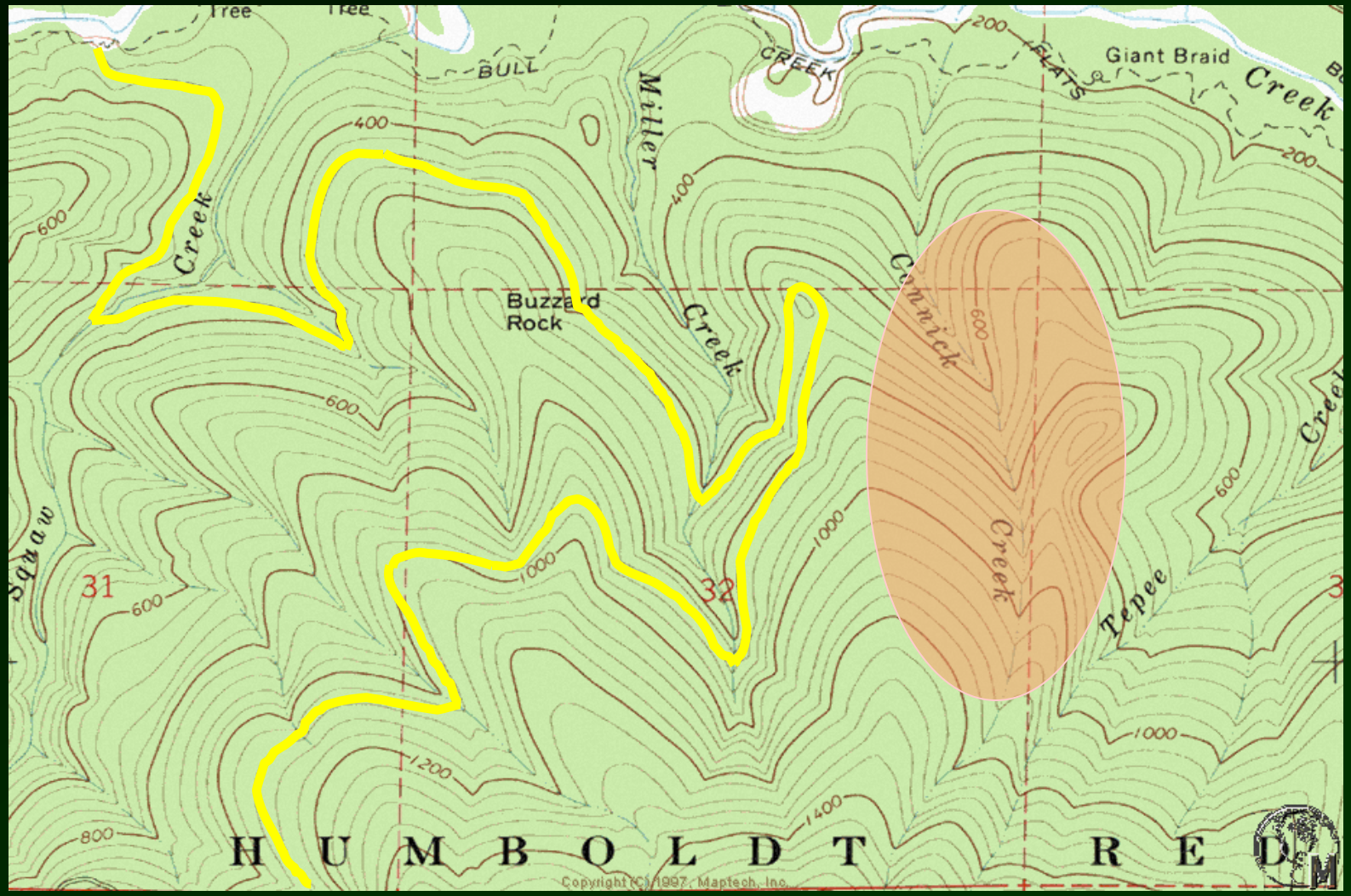



160’ elevation / 2,000’
of run = .08%
9%
10%
9%
6%
7%
8%

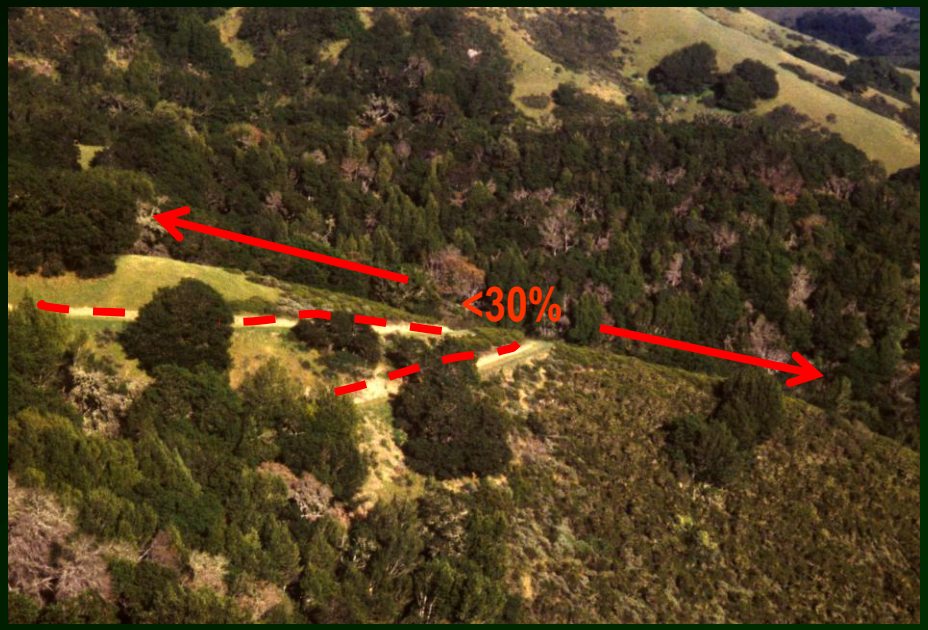
If the Average Linear Grade Exceeds the Maximum Sustainable Grade Additional Linear Run may be Required



To Gain Additional Linear Run a Topographical Turn Should be Used First (control point)

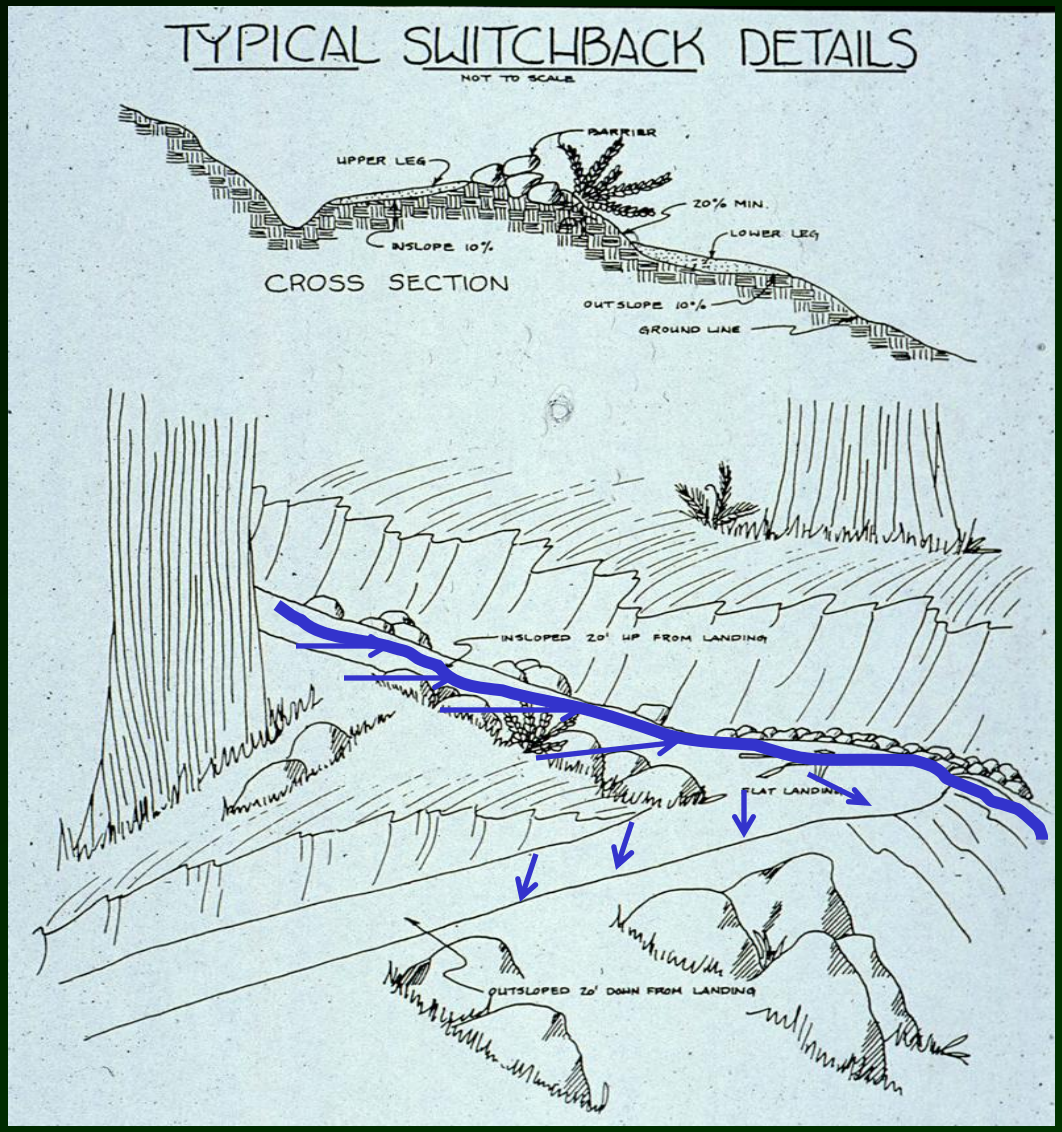


If a Topographic Turn Is Not Available Then a Climbing Turn or Switchback Can Be Used to Gain Linear Run

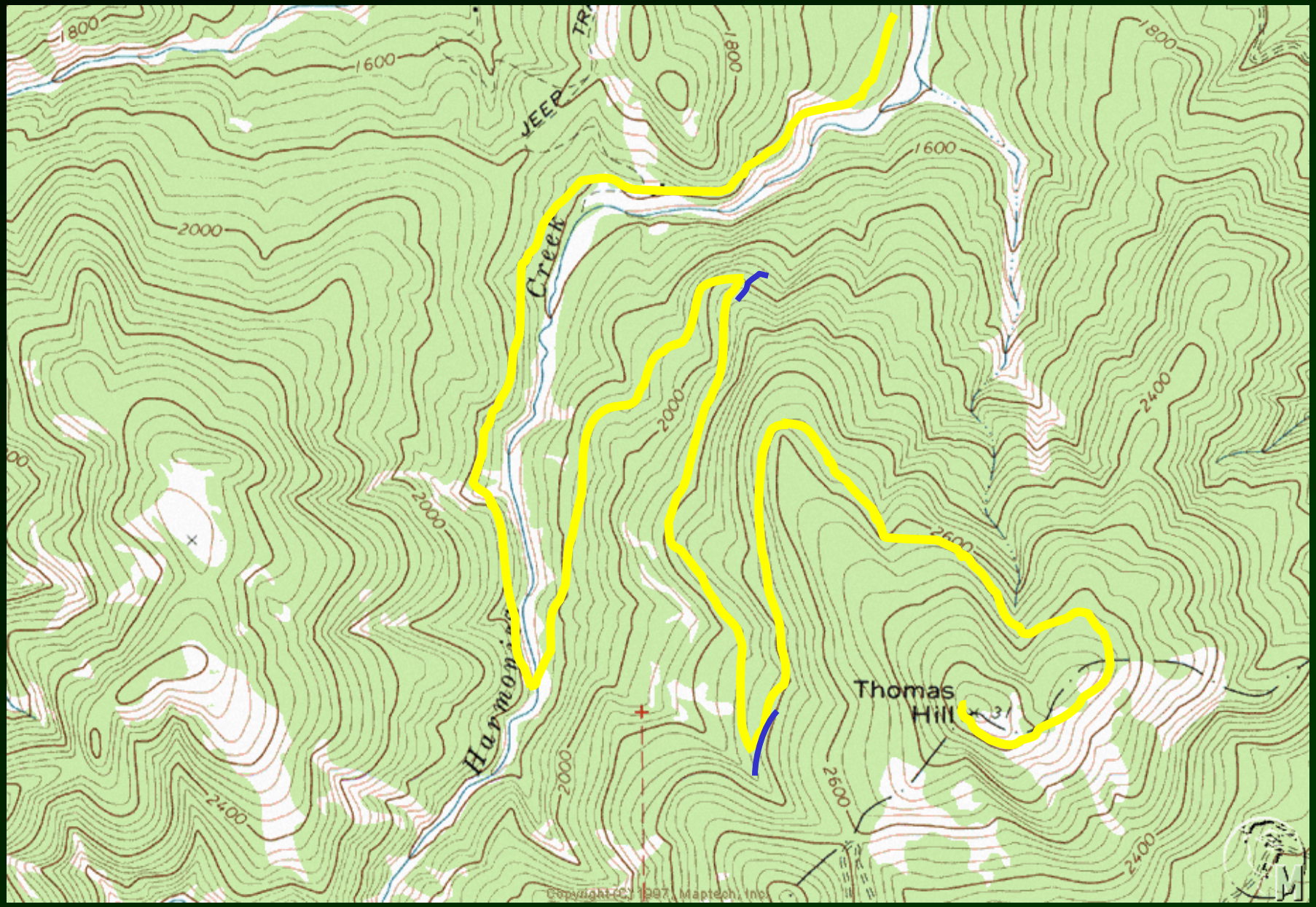


Climbing Turns and Switchbacks Need to Be Properly Placed and Located (control point)

Location Must Facilitate Drainage off of the Corner or Turn (Switchback/Climbing Turn Design)



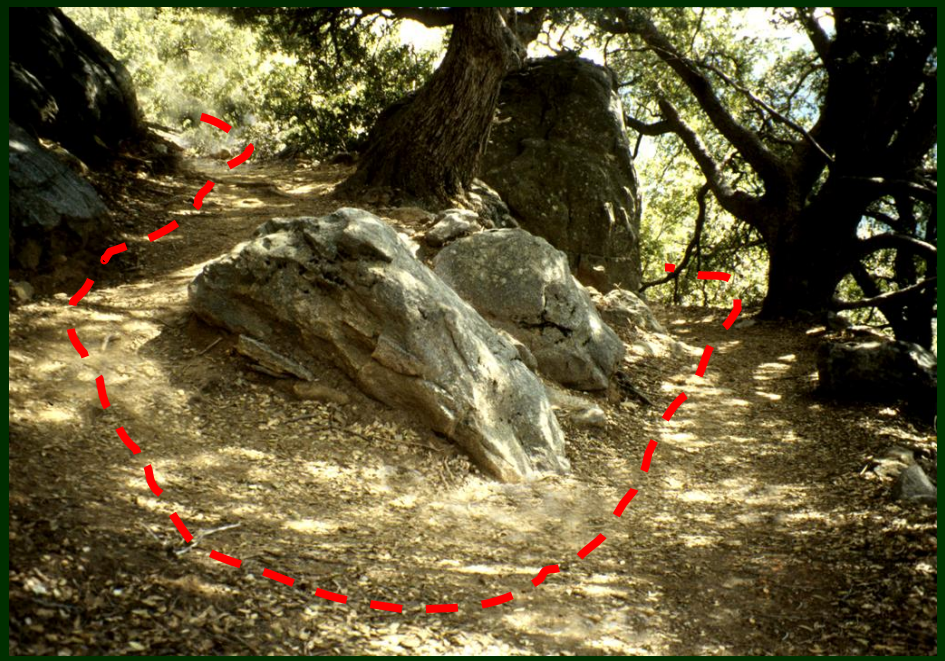
Use a Ridge Nose or a Swale/Drainage



There Must Be Good Separation Between the Two Legs to Prevent Cutting

Utilize a Break in Slope on the Hillside to Gain Vertical Separation Between the Legs

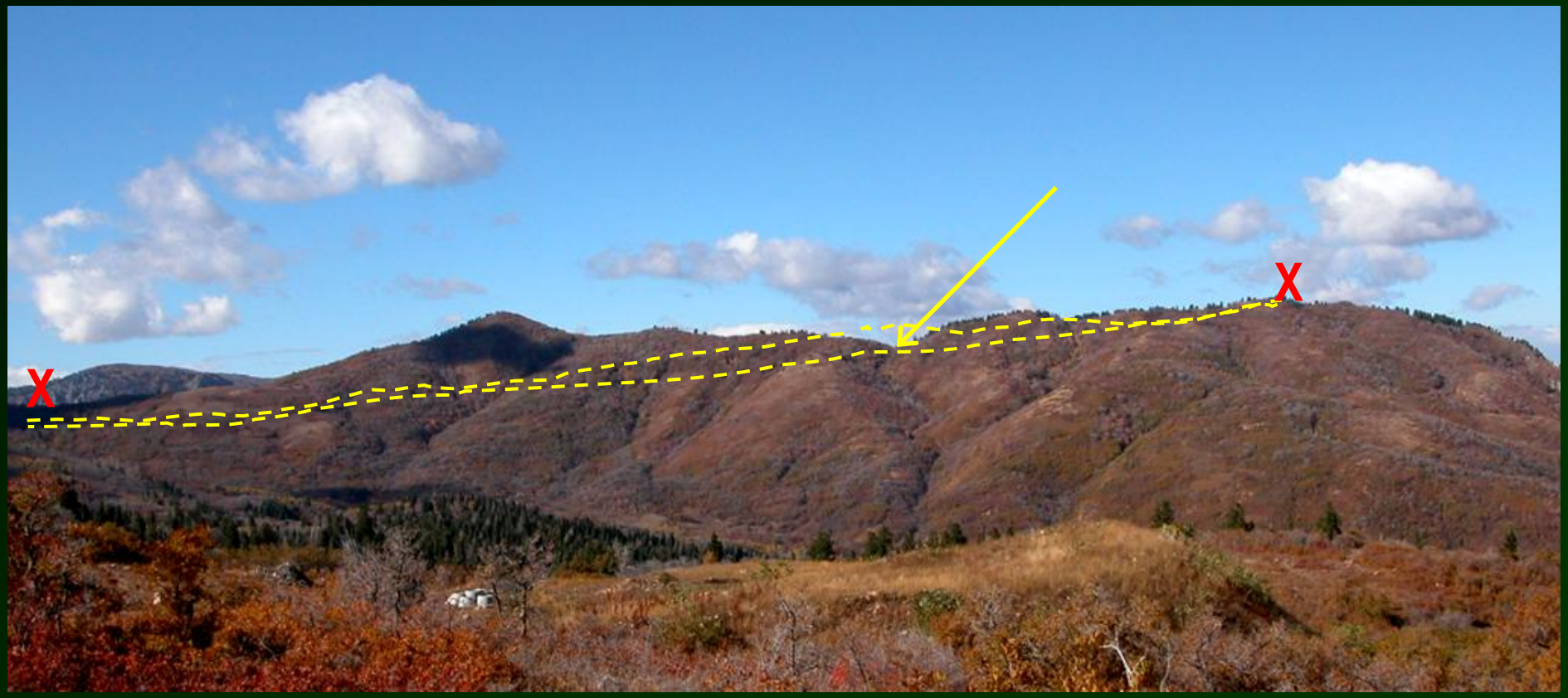
Utilize Trees, Rocks and Brush to Provide a Barrier Between the Two Legs. Proper Location will help Reduce Linear Grades



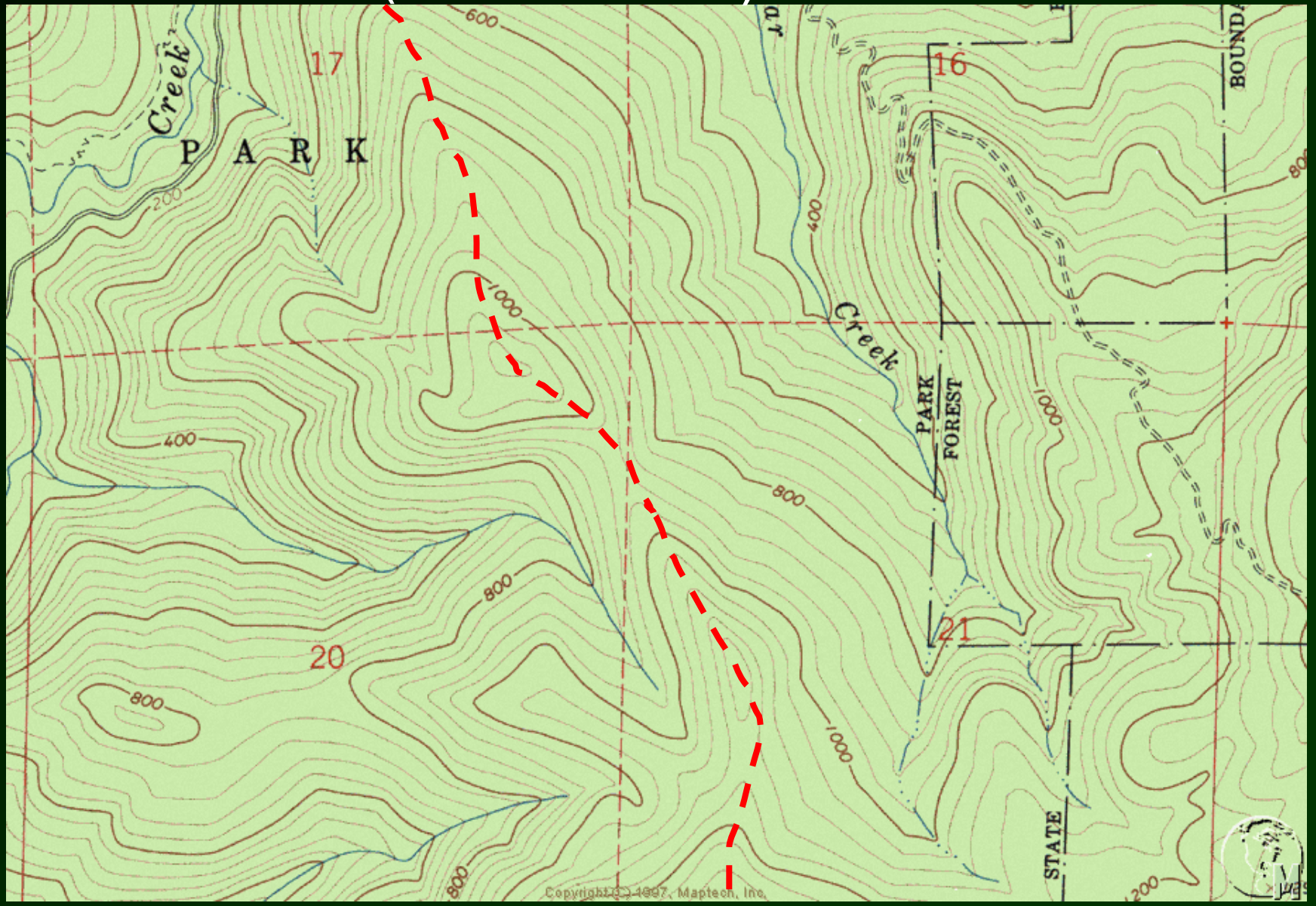
Incorporating Vistas into Switchback Corners will Help Prevent Cutting

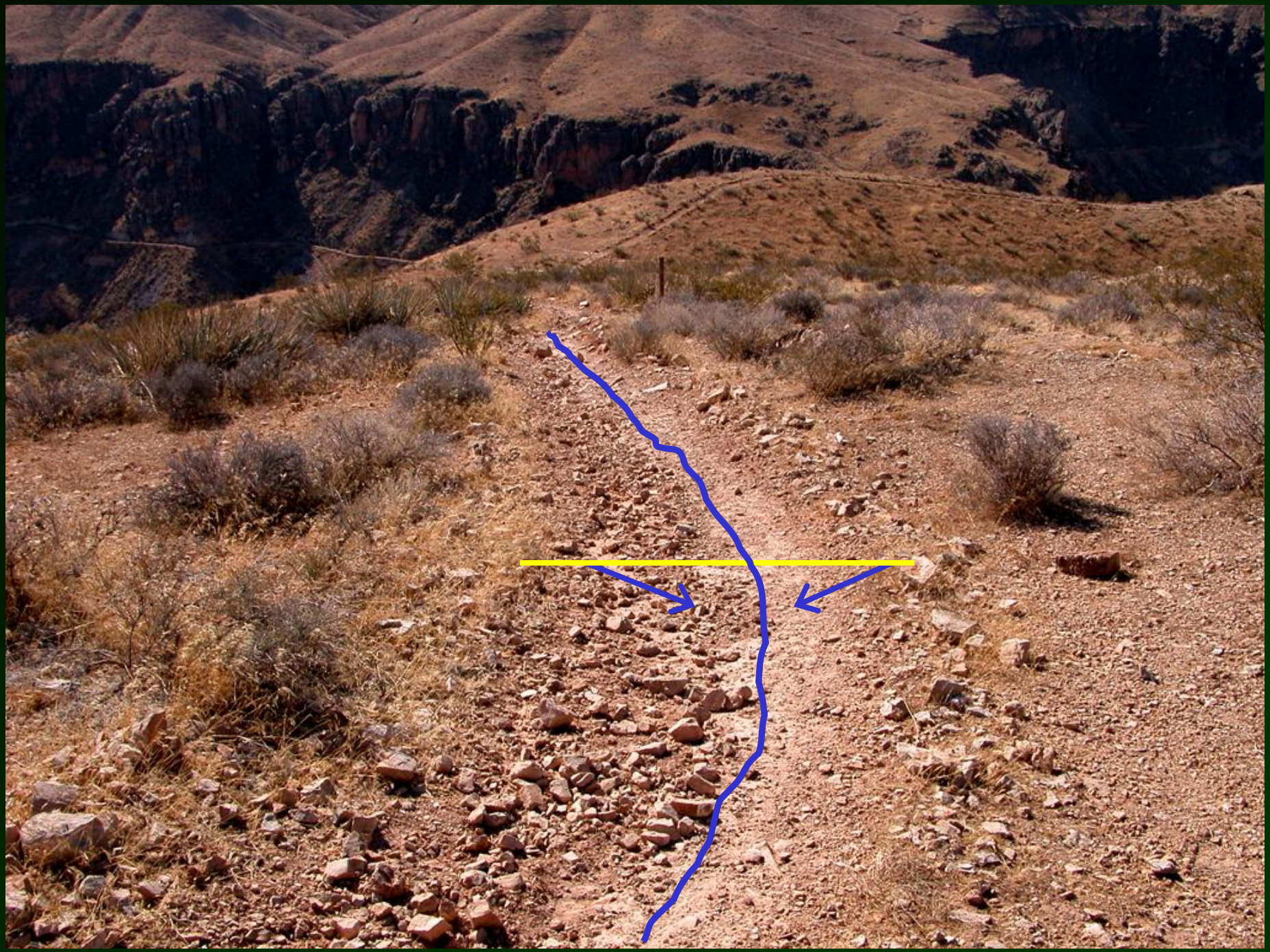
When Using Multiple Switchbacks Maximize the Distance Between Each Switchback to Eliminate "Stacking"

Topographic Features Such as Saddles can Also be Control Points

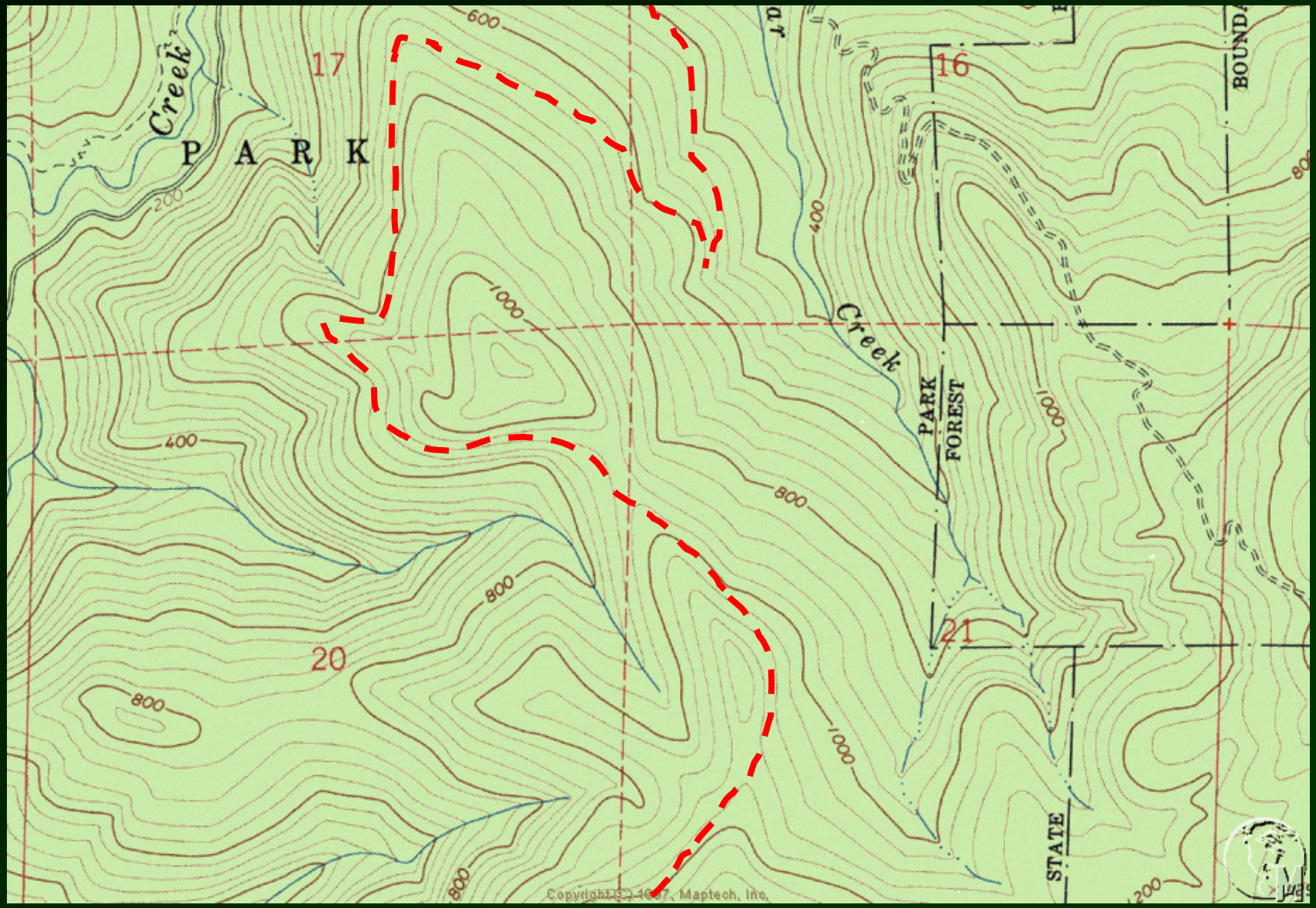


Laying Out Trails on Top of Ridges Should Be Avoided (Control Point)





Place Them on the Side of the Ridge and Cross Over at Saddles to Provide Alternate Views



Flat Poorly Drained Land Should be Avoided (Control Point)

Luke Prairie
Blue Slide
Shoo Fly
Creek
FOREST
Tall Tree
250
244
216
193
Bull
Giant Tree
Iron Tree
BULL
CREEK
Miller
Creek
Giant Braid
FLATS
Creek
Upper Bull Creek Flat
TRAIL
Buzzard Rock
Connick
Creek
Creek
Creek
28
29
32
33
400
600
800
200
1000
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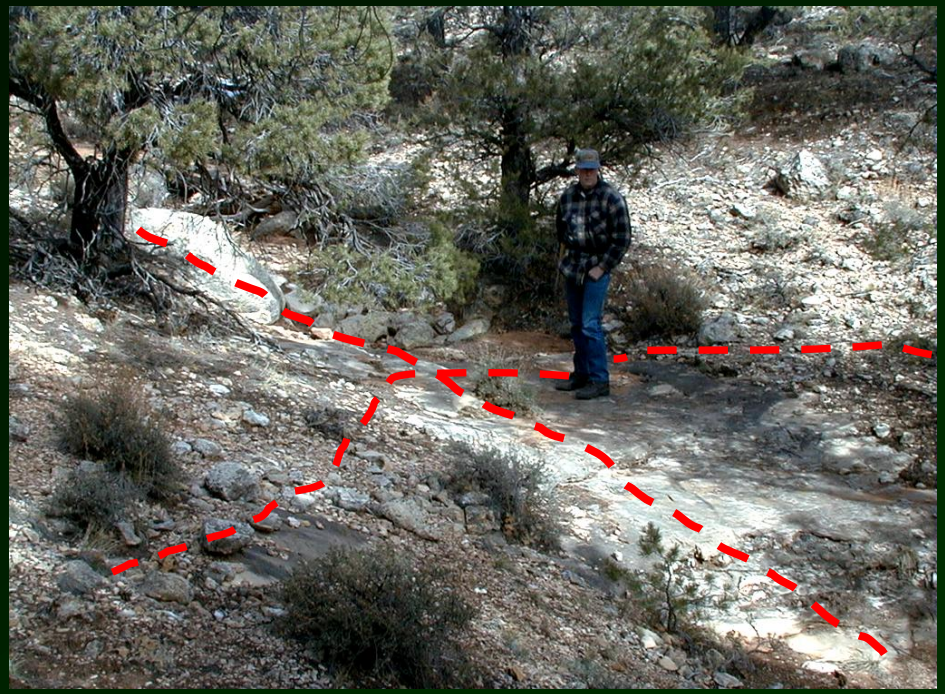
Meadows and Open Prairies Should Be Avoided, Trail Alignments Should Skirt the Edges If Possible (Control Point)

Drainage Crossings are Identified that Best Meet Proper Design Criteria (Control Point)

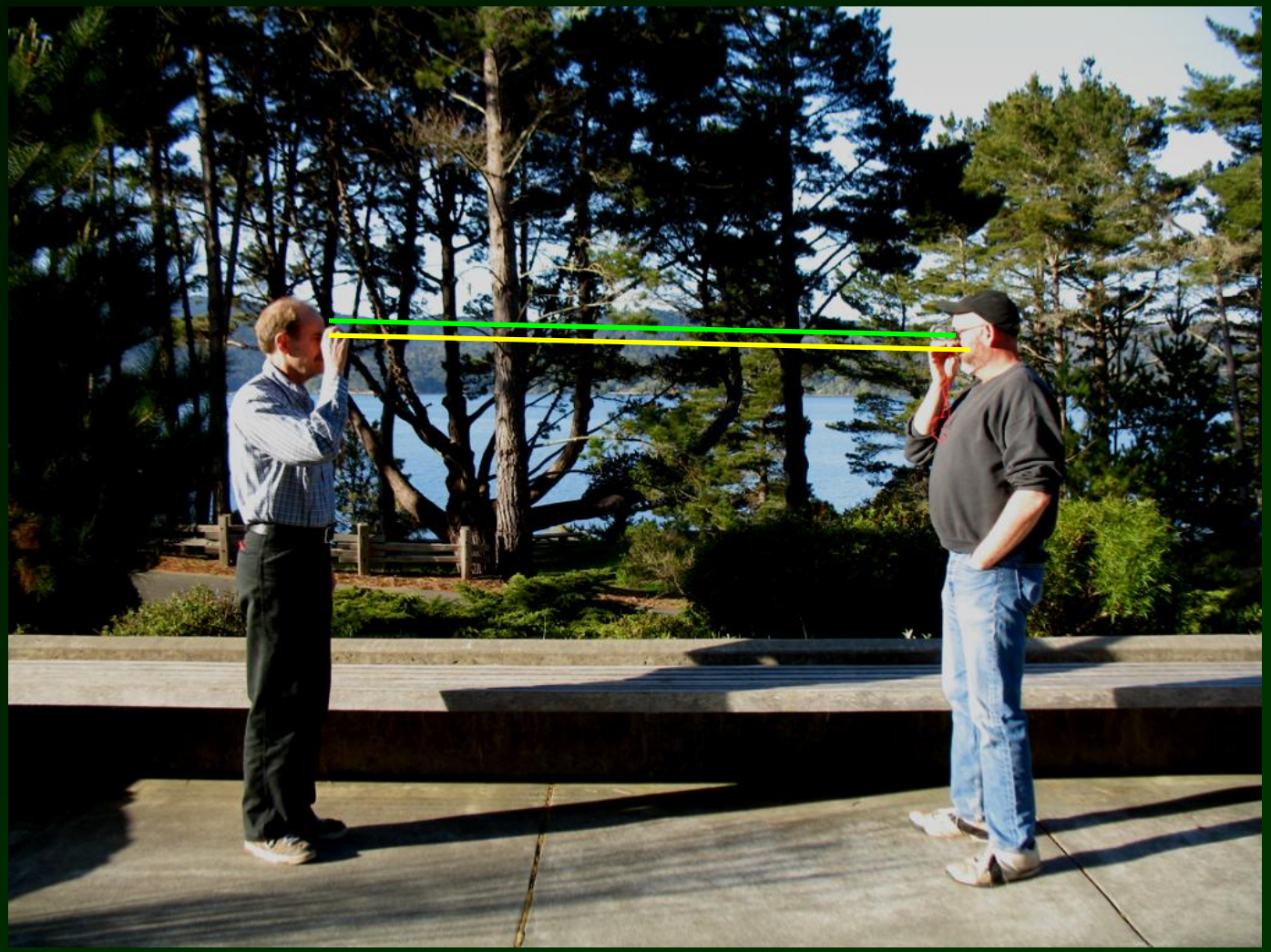
Drainage Crossings that Facilitate Instream Structures Require Moderate Gradients With (nick points) and Gentle Sloping Banks



Drainage Crossings that Require Bridges must be Evaluated for High Water Levels, Stream Bank Heights and Structural Stability

The Flagging Process

Prior to Flagging Establish Horizontal Reference Points on Each Team Member Using a Clinometer or Abney Hand Level



Sometimes there is too much height differences to establish a reliable reference point

Establish Flagging Teams and Their Individual Roles

With a Two Person Team The Shooter takes the Front Position so the Shooter Can See the Upcoming Terrain

The Shooter Walks to a Location at the Approximate Prescribed Grade Staying on Contour

The Shooter Locates Their Reference Point on their Partner and Moves up or Down Slope to the Prescribed Grade

In Heavy Brush and Trees the Partner Uses Colored Flagging to Highlight Their Reference Point

Once on Grade the Shooter Scuffs the Ground to Mark the Location Where They Were Standing

The Shooter Then Places a Flag Marking Trail Grade

Rolled Flagging is Tied to Vegetation in Brushy or Forested Areas

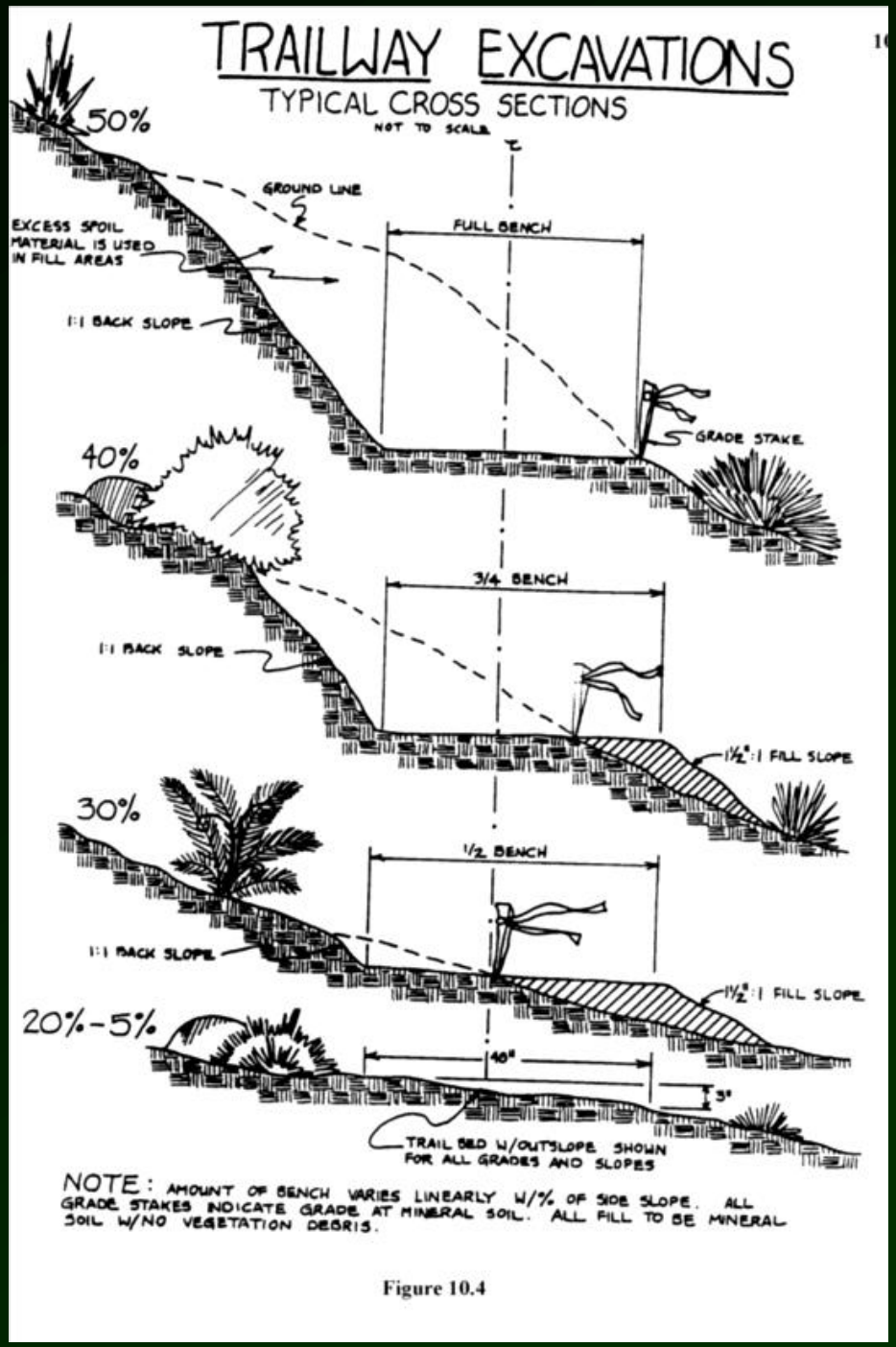
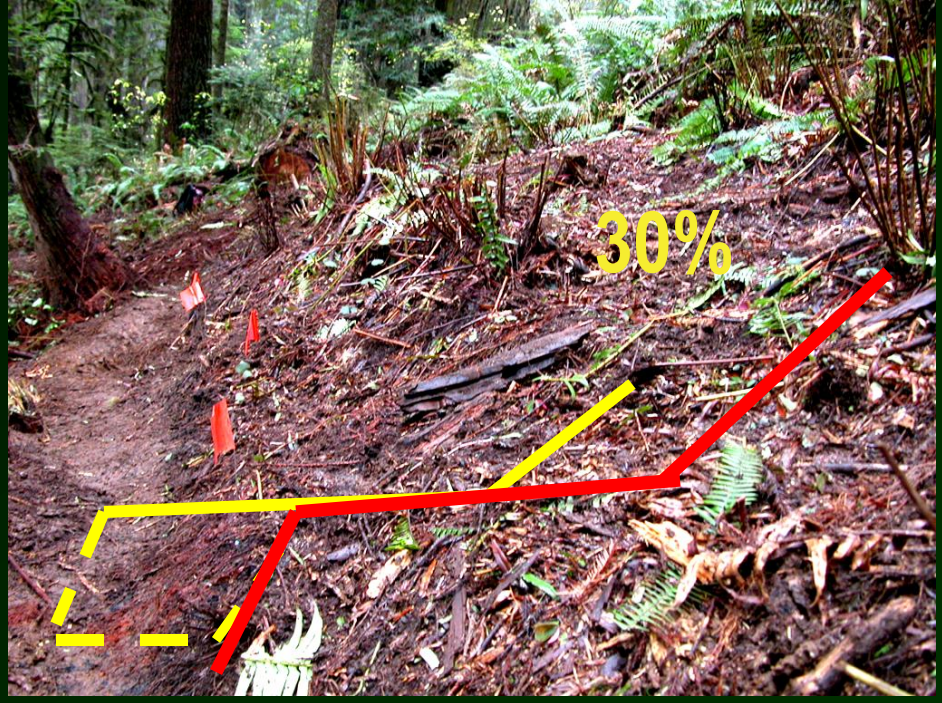

TRAILWAY EXCAVATIONS
TYPICAL CROSS SECTIONS
NOT TO SCALE
50%
GROUND LINE
EXCESS SPOIL MATERIAL IS USED IN FILL AREAS
FULL BENCH
BACK SLOPE
GRADE STAKE
40%
3/4 BENCH
BACK SLOPE
1½:1 FILL SLOPE
30%
1/2 BENCH
BACK SLOPE
1½:1 FILL SLOPE
20%-5%
40"
3"
TRAIL BED W/OUTSLOPE SHOWN FOR ALL GRADES AND SLOPES
NOTE: AMOUNT OF BENCH VARIES LINEARLY W/% OF SIDE SLOPE. ALL GRADE STAKES INDICATE GRADE AT MINERAL SOIL. ALL FILL TO BE MINERAL SOIL W/NO VEGETATION DEBRIS.

Figure 10.4

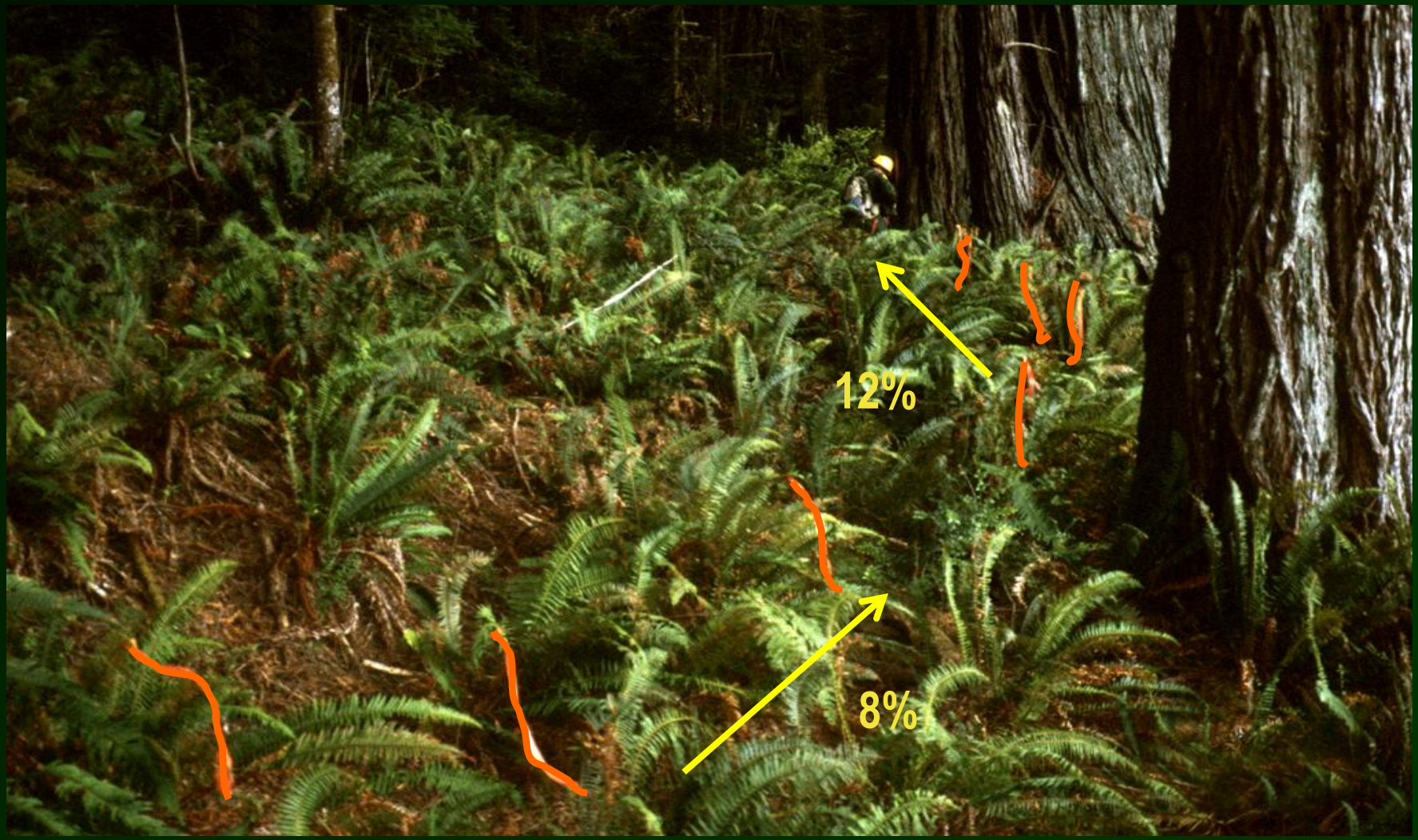

30%

50%

The Shooter Moves Forward for the Next Shot and the Partner Moves to Where the Shooter Previously Stood

Be Careful Not to Shoot Across Topographic Features

When Natural Features (Rocks &Trees) Require Grade Adjustments the Flag Line Needs to Be Readjusted to even out the Grade



9%

When Flagging in and out of a Stream, the Downhill Leg Needs to Level off or Climb for a Short Distance

The Initial Flag Line Should Be Loose Flagged. Tight Flagging Is Performed Once the Loose Flagging Is Completed

Write Prescriptions for Additional Trail Structures

Trail Layout and Trail Structures Prescribed Should Always Consider Accessibility First

Identify Potential Sources for Native Construction Materials

When Trail Structures are needed the Design and Materials Need to be Consistent with the Environment and Architecture

After the Trail Alignment has Been Brushed it will Need to be Re-flagged

Good Trail Layout Follows a Process

- Identify user groups and design standards
- Perform reconnaissance to evaluate the landform
- Careful observation of the land is required
- Develop a thorough mental image of the land
- Identify linear grade limits of the landform
- Identify major and minor control points
- Determine linear grades between minor controls
- Locate the best possible trail route
- Flag between the control points

Good Trail Layout Follows a Process

- Identify local material sources and develop prescriptions for trail structures
- Trail layout and design requires the knowledge and application of a variety of disciplines